SCIENCE

FRIDAY, JULY 23, 1915

CONTENTS

Forty Years' Fluctuations in Mathematical Research: PROFESSOR H. S. WHITE..... 105

Nicholai Alexeyevich Oumov: LEO PASVOLSKY 113

Classification of Technical Literature..... 115

The Nineteenth International Congress of Americanists 116

Scientific Notes and News 116

University and Educational News 121

Discussion and Correspondence:—

The Meridional Deviation of a Falling Body: PROFESSOR WM. H. ROEVER. *Vegetative Regeneration of Alfalfa:* ORVILLE T. WILSON. 122

Quotations:—

The Organization of Science in Great Britain 127

Scientific Books:—

Horsburgh's Modern Instruments and Methods of Calculation: PROFESSOR DAVID EUGENE SMITH. *Hertwig's Die Elemente der Entwicklungslehre des Menschen und der Wirbeltiere:* PROFESSOR FREDERIC T. LEWIS. 128

Special Articles:—

Electrical Density and Absorption of β-rays: PROFESSOR FERNANDO SANFORD. *The Belly River Beds of Alberta and the Judith River Beds of Montana:* CHARLES H. STERNBERG. *The Travertine Record of Blake Sea:* DR. D. T. MACDOUGAL AND GODFREY SYKES... 130

Societies and Academies:—

The Anthropological Society of Washington: DR. DANIEL FOLKMAR 134

MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

FORTY YEARS' FLUCTUATIONS IN MATHEMATICAL RESEARCH[1]

IN the year 1870 was published the first volume of the *Jahrbuch über die Fortschritte der Mathematik*, a new venture in the mathematical world. It was intended to relieve students and investigators from the necessity of searching through all available recent books and serials in the quest of any particular topic, or in the effort to keep posted on the discoveries of current interest. Similar attempts have been made, both before and since 1870, in other fields of science; and their effect and influence have been so marked that even the general reader has now Poole's Index and its successors, attempting in a less minute way the same service for general periodical literature. Under each title of book or article the *Jahrbuch* gives a brief analysis, sometimes a criticism, so that the reader follows up only those articles whose actual content proves important for him.

At the outset the expectation was confidently expressed that the *Jahrbuch* would appear within six months after the close of its year. But serials were slow in reaching the office, there were from twenty to forty referees, and once a printer's strike interposed for half a year; so that three years often elapsed instead of six months. Twice a double volume was issued in the hope of lessening the delay; but it soon fell back, and now our most recent volume covers the year 1909. These voluminous handbooks, now covering forty-two years and occupying eight feet of shelf-room, offer op-

[1] Read before the Vassar Faculty Club, and the Columbia Mathematical Colloquium, February, 1914.

portunity for certain inquiries which without them would be futile; and first, for questions quite impersonal and general.

One's first impression, on inspecting this series, is that the number of authors of books and contributors to *Acta eruditorum, Berichte der Akademie, Comptes rendus, Transactions* or *Journals* must have increased surprisingly during forty years. So we count sample volumes, say those for 1875 and 1905. In the former, the number of serials reviewed and the number of writers were, respectively, about 110 and 510; in the latter volume these numbers are 180 and 1,880. To determine more definitely the quantity of mathematical literature represented, two methods suggest themselves. One is to assume that the number of *pages* filled by those reviews is proportional, on the average, to the quantity of literature published each year; or, if it seems more reasonable, proportional to the number and importance of ideas developed. The other is to count the titles listed in each table of contents, and take those for a measure. Diagrams are here shown, giving the results of both methods, the years being set at equal intervals along a horizontal base, and their output in pages or in titles being set off upward. A broken line joins

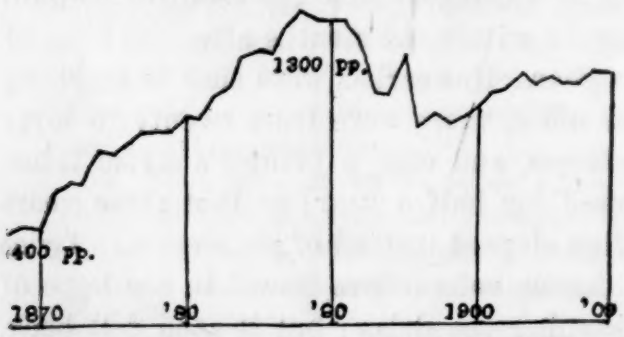


Fig. 1. *Jahrbuch über die Fortschritte der Mathematik.* Increase in size during forty years.

the points so marked; thus the area between graph and baseline, widening from decade to decade with one or two interruptions, conveys a fair idea of the growth in this kind of literature. One of the interruptions comes in the years 1893–4, where a double volume was issued in an attempt to overtake the flight of time. It shows presumably that considerable matter properly belonging in those years was pushed into the preceding and the following volume, swelling them unduly. The general impression

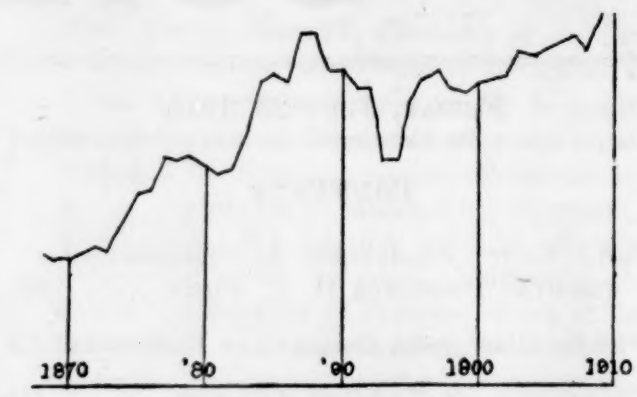


Fig. 2. Annual Number of Titles of Mathematical Articles and Books, 1868–1909.

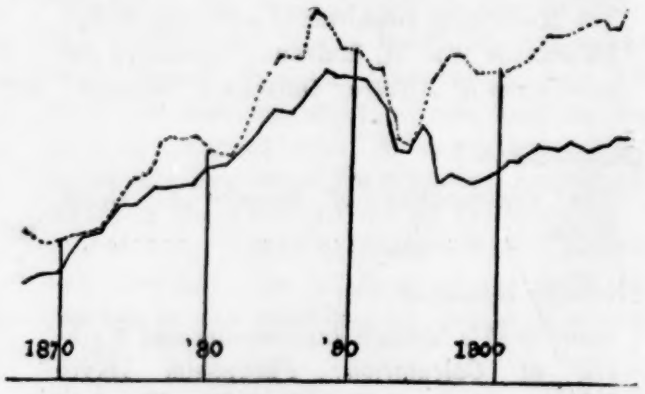


Fig. 3. Number of Pages; Number of Titles, for Comparison, in Dotted Curve.

from these two curves (if I may call them so) is that the two methods agree approximately, and that either one may be used as may be convenient. But we shall test this further on particular divisions of the science.

We see that the annual publication has doubled during the four decades, and considerably more; also that the space given to each review has decreased. Causes for the first are the increased attendance at universities, the general advance in zeal for research as a part of the great onward move-

ment in natural science, and the increase in funds available to support publication of new results. For the second fact, the condensation of reviews, it is certain that much space is saved by the possibility of reference to earlier volumes where similar articles were reported; and it may be suspected that the haste to print has given us many articles of little importance; and further, it is increasingly necessary to save the time of the reader—Fechner's law may perhaps hold here, as in the ratio between nerve-stimuli and sensations: the referees are competent, busy workers in various departments of research, and fatigue effects must be looked for in their treatment of minor matters at least.

For convenience I separate the list of contents into five principal groups, each group embracing several chapters or sections; these will suffice at least for a first study. They are philosophy and biography, algebra, analysis, geometry and applied mathematics. To any specialist this seems too coarse a division for any definite result, but we are seeking general information. Our division *algebra* includes not only the theory of equations and their systems, but also such diverse subjects as Galois groups, theory of integers and other numbers, determinants, invariants of linear substitutions, probability and series. So too *analysis* covers a long range, from the elements of differential and integral calculus to the theory of real and complex functions of one or of several variables, general and particular. *Geometry* covers both the Euclidean and non-Euclidean, synthetic and analytic, the elementary and much that is so advanced as to be hardly distinguishable from algebra or from abstract logic. So *Mechanics,* all branches of mathematical physics, astronomy, geodesy and even meteorology are combined under the single rubric, *Applied Mathematics.*

There is a possibility of testing roughly those data, by comparison through the years 1891–1909 with the *Revue Semestrille,* a briefer report issued half-yearly and with less delay by the mathematical societies of the Netherlands, chiefly of Amsterdam. The comparison can not be quite satisfactory because the *Revue* classifies one article often under several rubrics, sometimes giving six or more references by different members for an article listed only once among the *Titles* in the *Jahrbuch.* Of course the tedious process of counting titles page by page through every volume is not to be thought of. Making this allowance, I have prepared with the help of Dr. Cowley, a collaborator on the staff of the *Revue,* graphs showing the numbers of

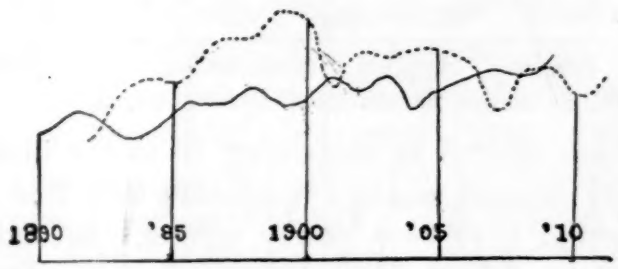


FIG. *A.* Algebra, Titles. *Jahrbuch,* Solid; *Revue Semestrielle,* Dotted Curve.

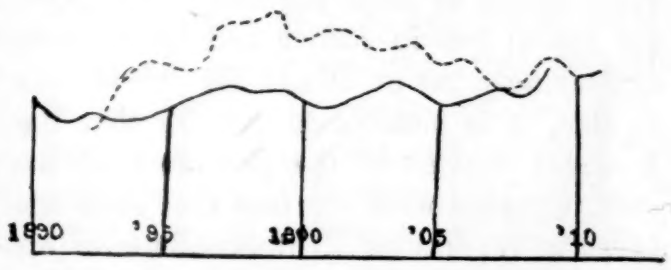


FIG. *B.* Analysis, Titles. *Jahrbuch,* Solid; *Revue Semestrielle,* Dotted Curve.

titles listed by both reports in the four topics, excluding philosophy and biography.

These may be considered satisfactory confirmation of the others, if we make two or three assumptions or observations. First, the scale adopted for comparison is probably too great on the *Jahrbuch* side. Titles here were measured in inches, and have

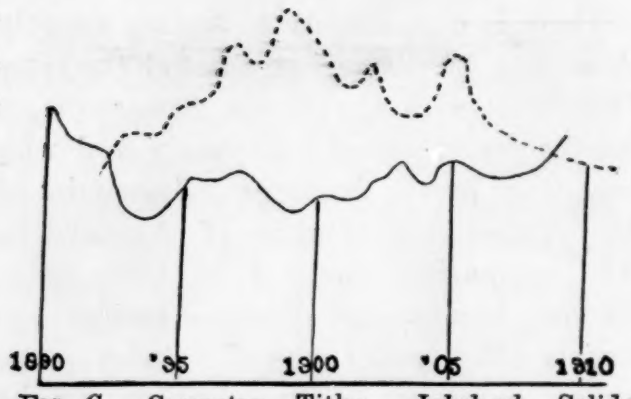


Fig. *C.* Geometry, Titles. *Jahrbuch,* Solid; *Revue Semestrielle,* Dotted Curve.

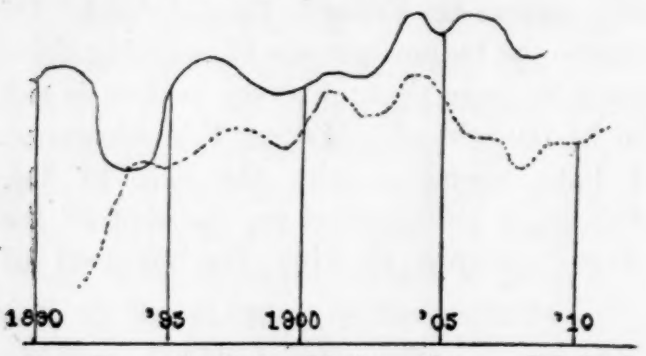


Fig. *D.* Applied Mathematics. *Jahrbuch,* Solid; *Revue Semestrielle,* Dotted Curve.

been plotted as containing 10 to the inch. By random samples it appears that 7 or 8 would have been nearly correct. Second: If by this correction the *Jahrbuch* curve were lowered relatively, still the divergence would be disproportionate for different years; less in earlier and later years, greater near the middle of the period. As to this, it is possible to surmise that the frequent change in the *personnel* of the staff, together with the fact that each one turns in reports on all the contents of his assigned periodicals rather than upon a list pertaining to his own few specialties, will explain much of the observed effect. In the first few years habits of work were not yet settled, and after several years it may easily have happened that cross-references of minor importance were found too numerous for utility and gradually reduced. Probably, thirdly, irregularities due to postponement or to lack of prompt arrival of publications would affect the *Revue* more markedly than the more leisurely *Jahrbuch.*

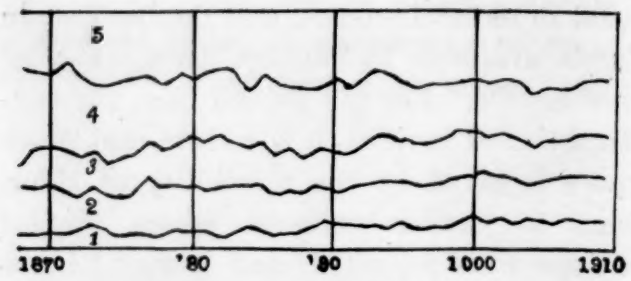
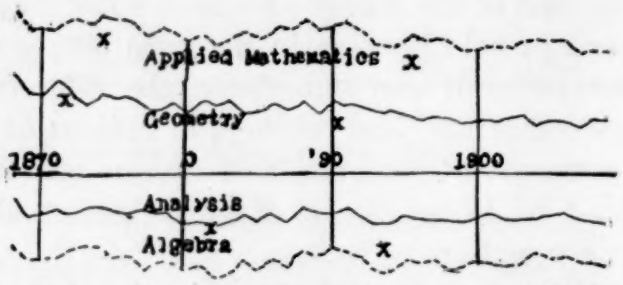


Fig. 4. Proportions of Titles in Large Divisions. (1) Philosophy, (2) Algebra, (3) Analysis, (4) Geometry, (5) Applied Mathematics.



Figs. 5–6. Proportional Numbers of Titles in Four General Divisions of Mathematics. (*x*, Maxima.)

I show graphs of the proportionate amounts (*i. e.*, percentages) of the successive volumes, that fall into the several divisions; the first with boundaries straight and parallel, like covers of a book, the second with a straight line separating the abstract algebra and analysis on one side from the more concrete geometry and applied mathematics on the other. In this latter the outer boundaries are parallel curves, and their fluctuations enable us to trace the occasional shift of interest toward concrete or abstract.

On this diagram it is noticeable that the proportions of writings in the different divisions are by no means constant. Roughly estimated, the averages are: Applied mathematics 30 per cent., geometry 25 per cent., analysis 20 per cent., algebra 18 per cent. and philosophy, history, etc., together 7 per cent. But there are certain times of wide variation from the average. In physics, for example, there is a period of increase from 1883 to 1890, a time when Maxwell's "Electricity and Magnetism," Rowland's researches in the spectrum,

Helmholtz's Faraday lecture, and certainly the influence of Thomson and Tait's great treatise on "Natural Philosophy," might help to explain the rapid growth of interest and discussion. The lesser, though well marked, influx of energy in the years following 1895 may be due in part to the discovery of radium and the new theories of electrons and atoms. Of course such surmises can only be verified or corrected by close examination of the subjects that are grouped together indiscriminately in this division.

Such fluctuations occur not only in these most concrete branches, but are discernible in all the others. Such variations in the choice of subjects for investigation one is tempted to call changes of fashion, so capricious or accidental do they appear to a superficial observer. On this same diagram, in geometry, note the disproportionate breadth of the stream through the '70's, and its slow narrowing thereafter. See in analysis, too, the breadth near 1880, and later, some expansion soon after 1890. Algebra enjoyed maximal periods not far from 1878, and has overflowed its usual boundaries again ever since 1899. The gradual augmentation in philosophy, history, biography might have been expected, but is also in part traceable to the influence of imitation and to vagaries in classification.

One may pick flaws in classification, but there are excuses, one of them in this very fact of changing fashions. For a set of categories that answer well enough in 1868 do not contain explicitly all the topics that interest even conservative mathematicians in 1880, still less in 1910. No long disquisition on this subject is needed, for nearly every one has some pet grievance against a much more elaborate arrangement, the Dewey system of classification of books. But also a part of the fault, in the case before us, lay in the imperfect office arrangements even more than in the system adopted. Against this source of error the more recent French system has guarded, by adopting numbers for a designating mark. Of course the *Jahrbuch,* published in Berlin, ignores this improvement, but it does from time to time add new titles to chapters and new subdivisions under them. My two complaints against the editors were first their lack of discrimination between two subjects called by the same name: theory of forms in the algebra of continuous variables, and theory of forms in the domain of whole numbers or integers. When looking for important memoirs on the one subject, one must always search with a careful eye the other chapter also. And in the second place they had made no place for any *Theory of Groups* except that concerned with permutations (hardly even for that until very recent years), and ignored completely the creation of a great new department of activity by *Sophus Lie* in 1870, under the same caption with a difference, viz., the "Theory of Continuous Groups."

In all this tabulation and construction of graphs, it has been assumed that one article is like another in importance, one idea as fertile as its rival, one name of an investigator no more to be noticed than any other. This assumption, however, is harmless, for it deceives nobody. As well try to convince a student of stars that all parts of the nightly sky are of equal brightness, that there are no luminaries of first magnitude and no Galaxy resplendent with its organized myriads! But in a first approximation we are at liberty to make errors, provided we do so with the consciousness that they are errors and that they call for subsequent discrimination and revision.

Look then at a few graphs relating to single divisions or subdivisions.

In 1868 and 1869 was published an epoch-making work, the "Geometry of Straight Lines," by Julius Plücker, professor of physics and mathematics at the University of Bonn. Unconsciously students of geometry had presumed that the space we live in must be conceived as built up of points, or minute bodies, having vanishing magnitude or dimension in all directions. Plücker pointed out that to the eye of pure mathematics it is just as true that space is built of *straight lines.* The intersection of the lines of geometry is no obstacle to such a theory, any more than if they were rays of starlight! With this new conception of space, amenable to a beautiful algebraic treatment, came a great stimulation of speculation and exploration in geometrical realms both old and new. *Plücker,* his brilliant pupil *Klein, Clifford* and *Cayley* are the centers of greatest energy in this movement, whose force persisted for twenty years and more. I show here a graph for geometry, no longer as a

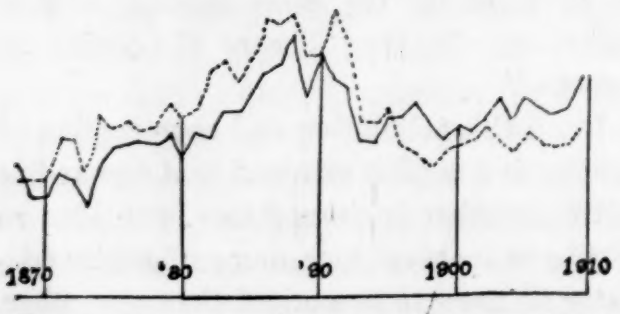


Fig. 7. Geometry, Number of Titles; Number of Pages, for Comparison, shown by Dotted Curve. Agreement, fair.

greater or less part of the entire range of mathematics, but measured, so to say, absolutely—the number of titles or of pages given to it in each annual volume of the *Jahrbuch.* Judged upon either basis, geometry seems to have doubled in rate of production from 1870 to 1890, then to have fallen off a third, to regain most of this loss after 1899.

In the universities of Germany the decline was decidedly more violent than this graph can show; for men trained in a specialty do not all change suddenly their interest or their line of study. So the new impulse, if it comes, will lag in its manifestation on this graph. Geometry was transplanted into Italy during the '80's, and the notion of *Group,* worked out in partial applications earlier by Klein, Sophus Lie, and their schools, was extended, energized and developed in larger geometric shape by young, ardent, brilliant sons of the men who in 1870 had created a new kingdom of Italy. A new society began to publish *Rendiconti* at Palermo ('88) and we note the point, about 1893, where this rising tide meets and overcomes the ebb of the German wave, Segre is here the great name, at first; Castelnuovo and Enriques soon rise to altitudes before unknown, algebraic *surfaces* now proving to be no less interesting than algebraic *curves* had been in the 70's and 80's.

Fig. 8. Above, Analytic Geometry, Titles; Below, Modern Synthetic Geometry (same scale).

Let us further distinguish, dividing geometry into the pure or synthetic, and the algebraic. Both had experienced revival in Germany, the synthetic geometry through a combination of influences, conspicuously through the publication of *Reye's* lectures in form pedagogically perfect, with full illustration and touched with that scientific fire which is almost poetic inspiration. Our graph is arranged to show on opposite sides of a base-line, by numbers of titles, the output of analytic and algebraic geometry above. the synthetic below. The ordinates are absolute, not percentages; and further argument is unnecessary to estab-

lish the thesis that research is ruled partly by fashion; the maximum of synthetic work about 1887, and its decline through

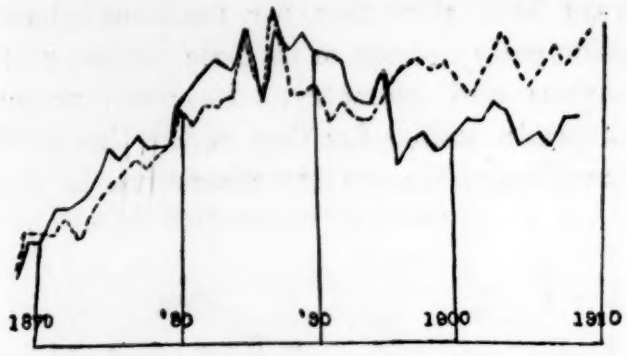


FIG. 9. Analysis, Pages; Titles, Dotted Curve. Both show a maximum about 1886, a minimum about 1895.

the following twenty years, is proof sufficient.

One graph shows the growth of what is called *analysis*, that great body of knowledge which takes its rise equally from calculus, from the algebra of imaginaries, from the intuitions and the critically refined developments of geometry, and from abstract logic: the common servant and chief ruler of the other branches of mathematics. The page-chart solid, the record of titles broken, both show a general increase in the amount of work, possibly a trebling in forty years. A first maximum appears before 1890, probably the culmination of waves

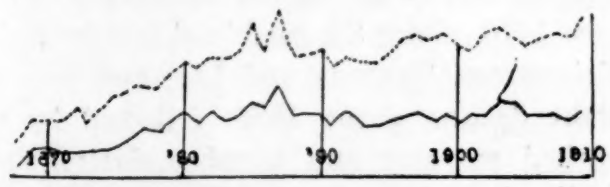


FIG. 10. Theory of Functions; Titles. Dotted Line: Analysis (Reduced).

set in motion by *Weierstrass* and *Fuchs* in Berlin, by *Riemann* in Göttingen, by *Hermite* in Paris, *Mittag-Leffler* in Stockholm, *Dini* and *Brioschi* in Italy. The great energy of these giant intellects was directed mainly to founding on a basis critically unassailable the theory of functions, before this time somewhat loose and uncertain, and to developing its particulars from general grounds, rather than by piecemeal as was the necessity earlier. So in the next graph we see how considerable a part of the growth of analysis prior to 1887 was due to activity in this—its central part, the theory of functions. But the fashion changes, and a new sweep of the curve upward does not occur until after 1900, when a new impulse comes from the theory of integral equations (not yet recognized as a separate field by the *Jahrbuch* editors) and from the influence of another master mind, *Hilbert* of Göttingen. In our own country too this branch of science is forwarded, notably at Harvard, Chicago and Yale.

One more example is perhaps the most striking of all. *Algebra* is shown first,

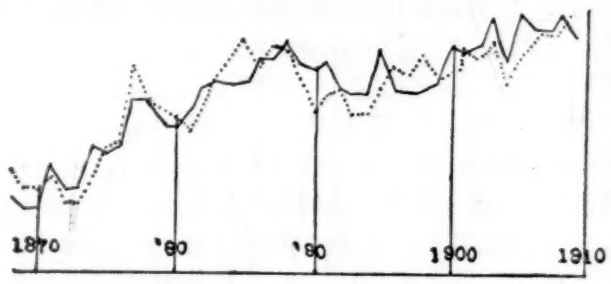


FIG. 11. Algebra, Including Series and Groups. Solid Line, Pages; Dotted Line, Titles.

pages on a solid curve, titles on a dotted one, quite nearly in accord. Each decade has its chief new subject for expansion, and growth is not far from steady. Equations, now up to the seventh and eighth degrees: determinants, invariants of linear groups of operations, and substitution groups all have had their years of plenty under this curve, and give it a strong, well-grown look. The part of this work that was shared most largely by our own countrymen is the theory of algebraic forms, quantics or invariants and covariants, as it is variously called. *Sylvester*, first professor of mathematics at Johns Hopkins University, had done fundamental work in this field in his youth, in the early 50's. At Baltimore the

eager requests of students led him back to that line of research, and many joined him in producing extensive and valuable work; much of it published in the *American Journal of Mathematics,* which he founded. In Germany the same subject engaged attention, at the same time or a little earlier, through the efforts of *Aronhold* at Berlin—a true pioneer; of *Clebsch* at Göttingen and *Gordan* at Erlangen, the last two founding in 1869 a new journal, the *Mathematische Annalen,* to facilitate the publication needed for the work of themselves and their enlarging circle of progressives.

The rapid rise, the climax and the decline to a low normal, in this theory of forms or *invariants,* is shown in a graph which amply repays this rapid statistical study.

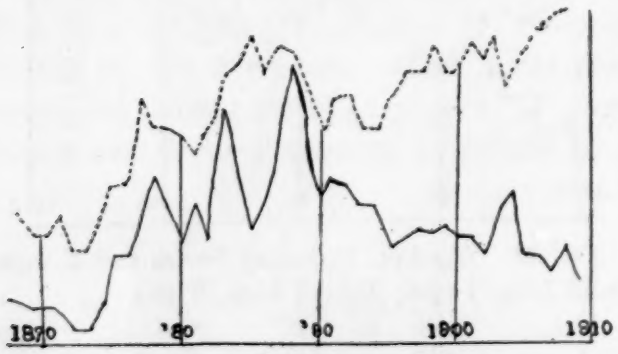


Fig. 12. Algebraic Forms, Invariants, etc.: Titles. Algebra, including Number-theory and Groups, Above (Reduced).

The solid curve shows the annual number of titles, while the dotted graph above. on smaller scale, shows how the general division, algebra, was fluctuating. Here the fashion reaches its acme before 1890, an increase twice as rapid as that of the main division; and declines most surprisingly. Sylvester returned to England in 1884; and in Germany a climactic series of discoveries by Hilbert set a temporary high mark, discouraging further effort for the time. But a later maximum, 1905, has in it a guarantee that growth is not impossible; this I do not pretend to explain, but the fact is obvious.

The field of differential equations has always held attraction for mathematicians, principally because of its close contact with physics and geometry. Its development naturally waited for that of the theory of functions. We see the researches in this

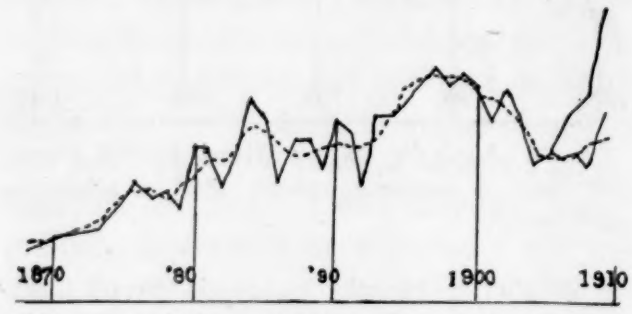


Fig. 13. Differential Equations: Titles. The dotted curve is averaged for three years.

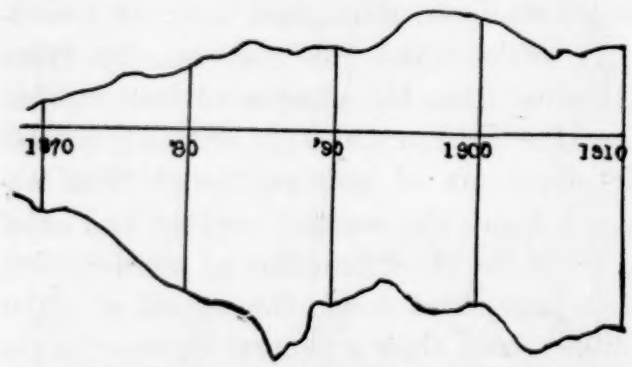


Fig. 14. Differential Equations Above; Below, the Residue of Analysis, Number of Titles.

department increasing in number slowly from 1870, under the combined influence of Weierstrass, Darboux and Lie; and note a slight decline about 1886, followed by a marked recovery and advance during the publication of lectures by Forsyth, Picard, Goursat and Painlevé. It is of interest to see the relative variation in differential equations on the one hand, and all the rest of analysis on the other.

Finally we examine in a separate diagram the fluctuation in absolute quantity of work on the mathematical theory of electricity and magnetism, and its ratio to the whole of applied mathematics. It remains less than one fourth of the whole, but rises after 1873

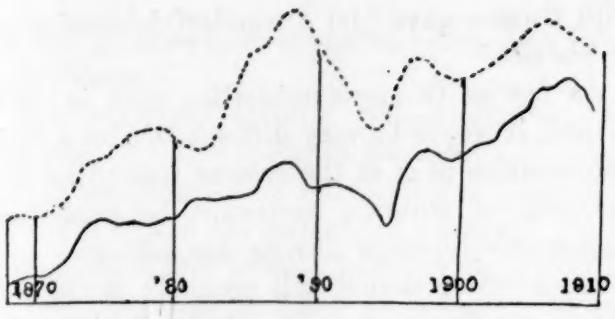


FIG. 15. Electricity and Magnetism; Dotted Line, Applied Mathematics (½ scale).

fairly steadily toward that fraction. It has been mentioned already that 1873 was the year of publication of Maxwell's "Electricity and Magnetism," and of Thomson and Tait's "Natural Philosophy." Maxwell's book appears in German translation in 1883. About 1880 Hertz began his remarkable experimental work verifying the theories of Faraday and Maxwell, with effects certainly contributory to the swelling of this tide. An apparent ebb near 1894 is explained in part by the increasing preoccupation of the referee in that department. Immediately after that date the increase of matter is resumed, partly under the new stimulus of Röntgen rays (1897) and of the electron theory (about 1902). By comparison, this special impulse seems not to be shared by the other departments of applied mathematics.

A careful inspection of these graphs might lead some specialists to lament the constant shifting of the center of mathematical interest. To students, however, who are about embarking on the sea of research, it may yield such profitable hints as the mariner draws from a chart of prevailing winds and currents.

H. S. WHITE
VASSAR COLLEGE

NICHOLAI ALEXEYEVICH OUMOV

THE recent death of Professor Nicholai Alexeyevich Oumov deprived Russia and the world of one of those remarkable men, unfortunately rare in our age of sharply defined specialization, in whom the powers of analysis and synthesis were so well blended together, as to enable him to be more than simply a great physicist, or a great chemist, or a great cosmographer, but a great philosopher.

It seems that modesty is a usual attribute of greatness, and Oumov was a modest man, indeed. Perhaps this accounts for the fact that he is so very little known in this country and in England, although the continental Europe, especially Germany, knows him well and has a profound respect for his works. His biography, however, seems to be a matter of knowledge only within a small circle of his countrymen, and it seems desirable to supply this want.

Oumov was born in 1846. To his father, a physician by profession, he owes his profound and wide interest in physical science. At the age of twenty-three he was graduated by the faculty of physics and mathematics of the University of Moscow. After his graduation he entered the car-construction works of Williams and Buchteeff. Later on he registered at the St. Petersburg Technological Institute, but after two months' attendance, he received an offer to return to the University of Moscow and prepare for a professorship there.

In 1871, however, he received appointment as a privat-docent in physics at the University of Odessa, where, several years later, he was promoted to professorship. In 1893 he was transferred to the University of Moscow, where he lectured successively on general, mathematical and experimental physics.

In 1905 the Russian universities received a charter of autonomy, by which the administration of the institutions was left in the hands of the university council, while the student body received certain privileges of self-government. However, towards the end of 1910, when the late Kasso became the Russian minister of education, attempts were made to deprive the universities of their autonomy. Early in 1911 a strike of the Moscow students, provoked by the agents of the police, as was later determined, gave the government the desired opportunity, and police control over the

internal affairs of the Moscow University was established.

The rector of the university, Dr. Manouilov, went to St. Petersburg to protest against this, pointing out the fact that the administration of the university was able to take the proper measures, without police interference. He was informed by the minister that if the state of affairs, as it then existed, did not please him, he was at liberty to pursue any course he chose.

Immediately upon his return to Moscow, Dr. Manouilov resigned from his post at the university. Several other professors, led by Oumov, also tendered their resignations, as a protest against the action of the government.

At that time Oumov, as the professor of experimental physics, was in charge of the celebrated physical institute of the university. Several days after he tendered his resignation, he was ordered to leave the university *immediately*. He was not even permitted to complete the experiments he had under way in his laboratories.

When this became known, a group of Moscow business men collected funds for the equipment of a new laboratory at the Free University of Sheniawsky, also at Moscow, and Oumov's work was transferred there. He remained at this university until his death.

This one fact is sufficient indication of the popularity which Oumov enjoyed in private life. He was beloved by his students, despite the fact that he was very exacting in his requirements. But it was well known that whenever the interests or the privileges of the student body were concerned. Oumov would always bring his powerful influence to bear upon his colleagues. Stern and dignifiedly scientific in the lecture hall and the laboratory, he was always kind, open-hearted and generous in private life. Student after student received financial assistance for the tuition from Oumov, but each one was made to promise never to mention this fact.

It is interesting that his favorite laboratory assistant, a man of scarcely any education, has recently been appointed to special instructorship at the university. His association with Oumov gave him a wonderful knowledge of physics.[1]

As far as Oumov's scientific work is concerned, it would be very difficult to give a full appreciation of it at the present time; like the majority of Russian professors he published comparatively little during his lifetime, and a considerable period will probably yet elapse before we have a complete study of his work.

There was, however, one characteristic feature of his scientific activity, of which we spoke at the very beginning. He was primarily a scientific philosopher, and it was this characteristic that made him different from other physicists. It was with a profoundly philosophical attitude that he regarded the different evolutionary phases of the human thought in the domain of physical phenomena. Professor Hvolson thus describes this characteristic side of Oumov's scientific make-up:

> He possessed a remarkable talent that enabled him to grasp quickly the essence of the views and the interpretations of the world, prevalent at the given moment, analyze the causes, often remote and deep-seated, that led to the rise of new hypotheses and theories, and then, by means of a clever synthesis, represent the results of the new evolutions of science.[2]

He was a splendid lecturer and he was often invited to speak at scientific congresses. In his speeches

> clear popular presentation of the results of new scientific works was blended with a philosophical interpretation of them, which often made them assume entirely new aspects.

The esteem in which Oumov was held by his fellow scientists in Russia may be seen from the fact that on the "First Russian Congress of Teachers of Physics, Chemistry and Cosmography," held in December, 1913, Oumov was elected president, as the "oldest Russian professor of physics, a profound thinker and a remarkable scientist." At this congress he delivered a famous speech on the "Evolution

[1] I owe these facts concerning Oumov's private life to my friend, Mr. E. Dourmashkin, of New York City, who had studied under Oumov at the University of Moscow.

[2] Professor O. Hvolson, "Retch," Petrograd, January 19, 1915.

of the Physical Sciences and Its Idealistic Significance."

His scientific activity was profound and many-sided. His splendid knowledge of physics, in the progress of which he was interested all his life, and his tremendous general erudition, enabled him to work in many departments of physical science. The names of some of his works are very suggestive of this manifoldness of interest: "A Theory of Action at a Distance and Its Application to the Laws of Electrostatics and Electrodynamics," "The Laws of the Solution of Certain Salts," "The Geometrical Significance of Frenkel's Integrals," "An Attempt of Discovering the Laws of Heat Energy in Chemical Reactions," "Uber eine Methode objektiver Darstellung der Eigenschaften des polarisierten Lichtes," "The Formation of Drops in a Magnetic and an Electric Field."

In physics he was equally at home in experimental methods and in the mathematical analysis. After leaving the University of Moscow, however, he gave himself up almost exclusively to theoretical work, especially in the domain of the principle of relativity. Some of his results in this direction were described in a speech on "The Characteristic Features and Problems of the Modern Scientific Thought," delivered before the general meeting of the second Mendelejev Congress.[3]

Oumov was the president of several scientific societies in which he was invariably the guiding spirit. For a short time he edited a splendid scientific magazine, *The Word of Science,* which, however, did not exist long.

LEO PASVOLSKY

NEW YORK CITY

CLASSIFICATION OF TECHNICAL LITERATURE

DELEGATES from about twenty national technical and scientific societies met in the United Engineering Society Building, 29 West 39th street, New York City, on May 21, 1915, to perfect a permanent organization, the purpose being to prepare a classification of the literature of applied science which might be generally accepted and adopted by these and other organizations.

There was a generally expressed opinion that such a classification, if properly prepared, might well serve as a basis for the filing of clippings, for cards in a card index, and for printed indexes; and that the publishers of technical periodicals might be induced to print against each important article the symbol of the appropriate class in this system, so that by clipping these articles a file might be easily made which would combine in one system these clippings, together with trade catalogues, maps, drawings, blue prints, photographs, pamphlets and letters classified by the same system.

By request, Mr. W. P. Cutter, the librarian of the Engineering Societies' Library, and a delegate from the American Institute of Mining Engineers, read a paper on "The Classification of Applied Science" in which, after describing the existing classifications, of one of which he is the author, he stated that, in his opinion, no one of these, although having excellent features, was complete and satisfactory enough to be worthy of general adoption. He outlined a plan whereby a central office could collate all the existing classifications, and, with the help of specialists in the various national societies interested, might compile a general system, which, although perhaps not absolutely perfect, might meet with general acceptance and adoption.

Permanent organization was effected by the election of the following officers: Chairman, Fred R. Low; secretary, W. P. Cutter; executive committee; the above, with Edgar Marburg, H. W. Peck, Samuel Sheldon.

It was agreed that a special invitation to participate by the appointment of a delegate be sent to other national societies which might be interested in the general plan.

The following societies were represented by delegates: Samuel Sheldon, library board, United Engineering Society; Richard Moldenke, American Foundrymen's Association; C. Clifford Kuh, Society for Electrical Development; Cullen W. Parmelee, American

[3] Unfortunately the speech is not available in this country.

Ceramic Society; Sullivan W. Jones, J. A. F. Cardiff, American Institute of Architects; Geo. F. Weston, American Society of Agricultural Engineers; F. L. Pryor, American Society of Refrigerating Engineers; H. W. Peck, American Gas Institute; Nicholas Hill, American Water Works Association; Edwin J. Prindle, L. P. Alford, L. P. Breckenridge, American Society of Mechanical Engineers; F. J. T. Stewart, National Fire Protection Association; J. J. Blackmore, American Society of Heating and Ventilating Engineers; C. F. Clarkson, Society of Automobile Engineers; F. L. Bishop, Society for the Promotion of Engineering Education; George R. Olshausen, U. S. Bureau of Standards; E. C. Crittenden, American Physical Society; Alfred Rigling, Franklin Institute; W. P. Cutter, American Institute of Mining Engineers; Edgar Marburg, American Society for Testing Materials; A. S. MacAllister, National Electric Light Association. American Electro-Chemical Society and Illuminating Engineering Society; C. E. Lindsay, American Railway Engineering Association; G. W. Lee, librarian.

The executive committee was charged with the task of enlarging the membership of the committee to include delegates from all similar national organizations, and the preparation of a plan for further action.

The delegates present expressed most hearty and enthusiastic personal interest in any system which might be worthy of general adoption; they could, of course, not promise, at this early date, anything more than moral support to the idea, reserving for themselves and for their societies the right to thoroughly examine any system that might be evolved before recommending its adoption.

The name adopted for this organization is "Joint Committee on Classification of Technical Literature," and the temporary address of the Secretary, Mr. W. P. Cutter, is 29 West 39th Street, New York City.

THE NINETEENTH INTERNATIONAL CONGRESS OF AMERICANISTS

In consequence of the war in Europe, the Washington meeting of the Congress, which was originally scheduled for October 5, 1915, was, with the general approval of the membership, indefinitely postponed. Since then it has become evident that the war may last for a long period, and that when it does end the conditions, economic and otherwise, may be such that a successful meeting can not be held for many years. Circumstances, however, have so shaped themselves as to make possible a well-attended session of the congress during the coming winter, notwithstanding the enforced absence of most of the European delegates. During Convocation Week of this year, a number of important scientific bodies, whose interests wholly or in part are closely related to those of the Americanists and whose membership is in a large measure the same, will meet in Washington. As this seemed to present an excellent opportunity for a meeting of the Americanists, the organizing committee took preliminary steps which assure intimate cooperation between the Congress and other learned bodies and submitted the proposal to hold the postponed session in cooperation or jointly with these organizations, to the vote of the members. The result of this vote was overwhelmingly in favor of the proposal. In consequence, the organizing committee feels authorized to announce that the session will be held in Washington, December 27–31, of this year; and that it will be held jointly or in cooperation with the Anthropological Section of the Pan-American Scientific Congress, the American Anthropological Association, the American Historical Association, the American Folklore Society, and the Archeological Institute of America. The program previously published will in the main be adhered to, excepting the field excursions; and the members are urged to communicate with the secretary in relation to the papers which they intend to present.

W. A. Holmes,
Chairman, O. C.
A. Hrdlička,
Secretary

SCIENTIFIC NOTES AND NEWS

Dr. W. W. Campbell, president of the American Association for the Advancement of

Science, will deliver an address at the opening session of the Pacific coast meeting, held at the Scottish Rite Auditorium, San Francisco, on the morning of August 2. Dr. C. W. Eliot, the retiring president of the association, is unable to be present.

THE thirteenth annual session of the South African Association for the Advancement of Science was held at Pretoria, from Monday, July 5, to Saturday, July 10, under the presidency of Mr. R. T. A. Innes, union astronomer.

THE Trail award and medal of the Linnean Society for 1915 has been presented to Dr. Leonard Doncaster, and the Linnean gold medal to Mr. J. H. Maiden, of Sydney, New South Wales.

AT its recent commencement Oberlin College conferred its doctorate of science on Dr. Charles A. Kofoid, professor of zoology in the University of California.

AT a convocation of the University of Oxford on June 25 the honorary degree of master of arts was conferred on Mr. Horatio P. Symonds, surgeon to the Radcliffe Infirmary, in recognition of his services to the Oxford Medical School.

AMONG knights created on King Albert's birthday the following are given in *Nature* as those engaged in scientific work: Mr. C. E. Fryer, superintending inspector of fisheries division of the Board of Agriculture and Fisheries since 1903; Mr. R. R. Gales, Indian Public Works Department, engineer-in-chief, Hardinge Bridge, Sara, Bengal; Dr. J. Mackenzie, F.R.S., lecturer on cardiac research at the London Hospital; Dr. T. Muir, F.R.S., superintendent-general of education, Province of the Cape of Good Hope, Union of South Africa; Mr. W. Pearce, director of William Pearce and Sons (Limited) and Spencer, Chapman, and Mensel (Limited), chemical manufacturers; Mr. E. Rigg, since 1898 superintendent of the operative department of the Royal Mint; Dr. W. N. Shaw, F. R. S., director of the Meteorological Office since 1905 and reader in meteorology in the University of London since 1907; Mr. W. Slingo, engineer-in-chief of the General Post Office.

MR. HERBERT LANG has been appointed assistant in mammalogy and Mr. James P. Chapin assistant in ornithology in the American Museum of Natural History. Mr. Lang and Mr. Chapin have also been elected life members of the museum in recognition of their efficient services in conducting the Congo expedition.

A GRANT of £50 has been made from the Balfour Fund of the University of Cambridge to enable Mr. G. Matthai, of Emmanuel College, to visit America in furtherance of his researches on the comparative anatomy and classification of the Madreporaria.

DR. FREDERICK BURR LA FORGE, of the staff of the Rockefeller Institute for Medical Research, has been appointed expert in organic chemistry in the U. S. Department of Agriculture. Dr. Benjamin S. Kline, also of the staff of the institute, has been appointed resident pathologist of the Montefiore Home for Chronic Invalids, and in connection with this appointment he has also undertaken work in the department of pathology of the College of Physicians and Surgeons, Columbia University.

DR. M. SULLIVAN has resigned from the division of soil fertility of the U. S. Department of Agriculture, Washington, D. C., and has accepted the position of bio-chemist of the U. S. Public Health Service. Dr. Sullivan will be engaged in the biochemical study of pellagra with headquarters at the pellagra hospital, Spartanburg, S. C.

DR. NEVIN M. FENNEMAN, profesor of geology at the University of Cincinnati, will have his year's leave of absence next year. Dr. Guy A. Tawney, professor of philosophy at Cincinnati, will return in the fall after a year's study at Oxford, England.

DR. LATTITIA M. SNOW, associate professor of botany in Wellesley College, has been granted a leave of absence for 1915–16. She expects to study in several institutions but her address for the year will be department of botany, University of Chicago.

MESSRS. H. E. ANTHONY and D. S. BALL have returned from an expedition to the moun-

tains of the Isthmus of Darien in eastern Panama, bringing with them for the American Museum of Natural History a collection of 1,100 birds and 250 mammals, many of which are new to the museum's collections and some undoubtedly new to science.

Dr. F. W. Pennell, associate curator of the New York Botanical Garden, is engaged in collecting in the Rocky Mountain region of Colorado, the Wahsatch Mountains of Utah and the Yellowstone National Park. The object of the trip is to study and collect plants of Scrophulariaceæ. *Pentstemon* and *Castilleja* are the principal genera to be found in this region. He also asks the cooperation of collectors throughout the country in respect to this family, as many critical problems can only be solved after the accumulation of ample material.

Dr. C. K. Schneider, of Vienna, who has recently been engaged in botanical exploration in western China, has been visiting the botanical institutions of the United States. Dr. Schneider is an authority on woody plants.

The schooner *George B. Cluett,* chartered by the Crocker Land relief expedition to go in quest of Donald B. MacMillan and the members of his party in Greenland, expected to sail from North Sydney, Nova Scotia, on July 10. Dr. Edmund Otis Hovey, of the American Musuem of Natural History, chairman of the Crocker Land Exploration Committee, is in charge.

On July 7, Professor C. J. Keyser, of Columbia University, delivered an address on "The Human Worth of Rigorous Thinking," before the mathematics section of the California High School Teachers' Association, at the University of California. On the evening of July 12 he presented a paper on science and religion before the Chit-Chat Club of San Francisco at a meeting held at the University Club of San Francisco.

Sir William Ramsay gave the address on July 1 at the annual meeting of the British Science Guild on "The National Organization of Science."

The annual general meeting of the Eugenics Education Society was held on July 1, when the presidential address was delivered by Major Leonard Darwin on the subject, "Eugenics during and after the War."

Dr. S. Alexander, professor of philosophy in the University of Manchester, has been appointed to the post of Gifford lecturer at the University of Glasgow for the period of 1916–1918.

Through the generosity of an anonymous donor, a lectureship has been established at the Mount Sinai Hospital named after the late Dr. Edward G. Janeway, who was for many years associated with the medical staff. The foundation has been created for the purpose of inviting important investigators to present the results of their work to the staff of the hospital.

The centenary of the birth of David Waldie, who suggested a trial of chloroform as an anesthetic to Sir James Simpson, has been commemorated by a bronze tablet, placed on the house in Linlithgow where he lived for some time. It has on it a portrait of Waldie, with an inscription in which he is described as a pioneer in anesthetic research.

In Science for July 9 the death was recorded of Professor Pieter Zeeman, of the University of Leiden. Unfortunately he was confused in this and other journals with Professor Pieter Zeeman, of the University of Amsterdam, the well-known discoverer of the magnetic resolution of spectral lines. Physicists will regret the loss of the distinguished professor of theoretical and geometrical mechanics in the University of Leiden, but will be glad to know that work of such fundamental importance as that done in the Amsterdam laboratory on the spectrum is not to be interrupted by the untimely death of its author.

Professor Frederick Prime, who held the chair of natural history in Girard College, Philadelphia, and had previously been professor of geology and metallurgy in Lafayette College, one of the secretaries of the American Philosophical Society, has died at the age of seventy years.

MRS. W. W. MAYO, aged ninety years, wife of the late Dr. W. W. Mayo, founder of the Mayo Clinic and Surgical Institute, Rochester, Minn., and mother of the distinguished surgeons, Dr. W. J. Mayo and Dr. C. H. Mayo, has died.

MR. HOWARD MARSH, master of Downing College, and professor of surgery in the University of Cambridge, died on June 24, aged seventy-five years.

DR. R. H. LOCK, inspector at the British Board of Agriculture and Fisheries, sometime fellow of Gonville and Caius College, Cambridge, died on June 26, at thirty-six years of age.

DR. G. C. M. MATHISON, known for his work on the physiology of respiration, and Lieutenant R. B. Woosnam, who has conducted zoological explorations, have been killed at the Dardanelles.

JOSEPH FARRIGAN, prominent mining engineer and entomologist, died at his home in St. Louis, on May 9, at the age of fifty-eight years. He was an authority on the aphididæ and a coworker with C. V. Riley, in the later seventies.

MR. F. H. NEVILLE, F.R.S., fellow of Sidney Sussex College, Cambridge, distinguished for his contributions to metallurgy, has died at the age of sixty-eight years.

CAPTAIN J. W. JENKINSON, late fellow of Exeter College, Oxford, and university lecturer in embryology, was killed on June 4 in the trenches in Gallipoli. He was forty-three years of age.

DR. CHAILLON, head of the anti-rabies department of the Pasteur Institute, having demanded and obtained the perilous mission of disinfecting a battlefield near the enemy's trenches, was killed in fulfilling this service.

DR. ALEXANDER R. CRAIG, of Chicago, secretary of the American Medical Association, reports that its membership has increased from 74,235 in 1914 to 76,020 in 1915.

THE twenty-second summer meeting of the American Mathematical Society will be held at the University of California and Stanford University, Tuesday to Thursday, August 3-5. Tuesday morning will be devoted to a joint session with the American Astronomical Society and Section A of the American Association for the Advancement of Science. Separate sessions of the Mathematical Society will be held on Tuesday afternoon and on Thursday at Berkeley and on Wednesday at Stanford University.

THE mid-summer field meet of the American Fern Society was held at Jamesville, N. Y. Members and their friends assembled on Tuesday evening, July 13, at the home of Mr. Wm. Spalding, 405 Comstock Ave., Syracuse, N. Y. Excursions were arranged under the guidance of Dr. Benedict, Dr. Todd and Mrs. H. E. Ronsier on days following.

THE preliminary list of awards by the Panama-Pacific International Exposition gives the Department of the Interior collective exhibit one grand prize. The exhibit of the Geological Survey receives one grand prize, four medals of honor, five gold medals, six silver medals, and two bronze medals. The Bureau of Mines receives one grand prize, six medals of honor, three gold medals, and three silver medals.

CONSTITUTIONALITY of the Illinois pure food law prohibiting in effect sale of a food preservative containing boric acid was upheld on June 21 by the Supreme Court. Justice Hughes, for the court, held that validity of the law must be upheld unless the defendant showed there was no doubt about boric acid being wholesome. The court held he had failed to do so.

A CIRCULAR has been issued by Dr. J. B. de Lacerda, the director of the National Museum in Rio de Janeiro, calling attention to the fact that on June 7, the collection of mineralogy in that institution was robbed of a green aquamarine weighing 11 kilos and 800 grams, two topazes, and a number of small diamonds. Dr. Lacerda requests mineralogists and directors of museums in North America to communicate instantly with him by telegraph, at his expense, in case these objects are offered for sale, and authorizes those to whom they

may be offered to take such steps as may be necessary to secure the return of the stolen property to the National Museum of Brazil.

The *American Museum Journal* states that through interest created by the Roosevelt South American expedition, the Museum has received six hundred birds and fifty mammals, presented by the Goeldi Museum of Pará, through its director of zoology, Dr. Emilie Snethlage. The members of the North American expedition when passing through Pará in May, 1914, called on Dr. Snethlage to examine the rich collections of Amazonian fauna which she, and her predecessor Doctor Goeldi, have amassed. Dr. Snethlage writes that shortly after the Roosevelt party passed through Pará she herself embarked on an expedition into the unexplored portions of the Upper Xingú, on which she was absent seven months.

Preparations for an enrollment of a hundred students at the summer session of the Puget Sound Marine Station have been made by Dr. Theodore C. Frye, acting dean of the college of science and director of the biological plant at Friday Harbor. Dr. Frye recently returned from the station, having spent several days there arranging for the season's work. Last year there were 43 students, practically all of whom were college graduates, doing research work. This year parties are expected from educational institutions in Illinois, Minnesota, Kansas, Nebraska and Utah. An improved water supply is afforded the station this year. Heretofore deep wells have furnished the water, which was not, however, good for experimental purposes. Friday Harbor now gets its supply from Echo Lake, and mineral content will no longer be a handicap. A new gravel road from the station to the town of Friday Harbor is another convenience completed this year. The shrimp steamer *Violet,* which was chartered last year, will again dredge for laboratory material, which abounds at the bottom of the harbor at a depth of about 100 fathoms.

The Lake Laboratory of the Ohio State University at Cedar Point, is this year under the direction of Professor Herbert Osborn, head of the department of zoology. Edward L. Fullmer, M.Sc., of Baldwin Wallace College at Berea, Ohio, will supervise the work in botany. Professor Frederick H. Krecker, of the department of zoology of the Ohio State University, and Professor S. R. Williams, of Miami University, will have charge of the work in zoology. Charles G. Shatzer, M.A., of Wittenberg College, will teach the classes on birds. The laboratory is situated on the shore of Sandusky Bay, where students have access to marshes, river, forests, sandy beaches and rocky islands. At Put-in-Bay is the United States fish hatchery, and glacial groves are at Kelly's Island.

On June 18, 1915, the Board of Estimate and Apportionment of New York City passed a resolution authorizing the issue of $100,000 corporate stock of the City of New York to provide means for permanent improvements at the Brooklyn Botanic Garden, including the completion of the laboratory building and plant houses. This action was taken following the generous offer of Mr. Alfred T. White, chairman of the Botanic Garden Committee of the Brooklyn Institute trustees, to secure a like sum by private subscription. The amount was subscribed by Mr. White, and the donors of the original endowment of the garden. Plans are now being prepared for the completion of the buildings, only one fifth of which are now erected. It is expected that ground will be broken this coming fall.

Nature calls attention to the forthcoming sale of Stonehenge by auction. The property is under the protection of the Ancient Monuments Act, which ensures its preservation; and the auctioneers, Messrs. Knight, Frank and Rutley, 20 Hanover Square, W., announce that Sir Cosmo Antrobus, who is only tenant for life, proposes, if his powers permit him to do so, to impose conditions providing for the public having access thereto for all time. It is hoped, however, that Stonehenge may be bought either by the government or by a learned society, and if any reasonable proposal be made for its acquisition with the intention of preserving the monument in the public interest, the auctioneers are instructed to facilitate a sale by private treaty before the auction.

ENGLISH journalists state that the British Institute of Industry and Science, acting in cooperation with the British Empire Exhibition Association, is promoting on a wide scale an exhibition of the national resources of the empire, which will be opened at the beginning of next year in a handsome building to be erected on the Aldwych site, where the existing offices of the institute are situated. The purpose of the exhibition is to demonstrate to the public, as well as to manufacturers and industrialists, the potentialities of the empire as contained in its natural resources. The various dominions and colonies are cooperating in the scheme, and each colony will, with the advice of the central body, organize its own particular section of the exhibition. The cost of the project will be about £50,000, which has been provided for through the generosity of the directors of the institute. The exhibition will, it is expected, remain open during the whole of next year.

UNIVERSITY AND EDUCATIONAL NEWS

THE Medical College of the University of Cincinnati has received several large donations during the past month. Mrs. Mary M. Emery promised the university the sum of $250,000 for a new Medical College Building, on the condition that an additional $250,000 be raised by July 1 for its equipment and maintenance. At the appointed time, Dean C. R. Holmes, of the College of Medicine, announced that $250,000 had been secured. The new structure will be located on grounds adjacent to those of the Cincinnati General Hospital, which occupies 24 buildings and covers 27 acres, and which offers unusual opportunities for clinical instruction. The sum of $30,000 has just been raised by citizens of Cincinnati for the purpose of maintaining for three years a chair of medicine in the Medical College. The chair will be known as the Frederick Forchheimer chair of medicine, in honor of the late Dr. Frederick Forchheimer, who was for years professor of medicine at the Medical College. Dr. Robert S. Morris, lately of Clifton Springs, New York, and formerly of Ann Arbor and of Johns Hopkins University, has been appointed to the new position.

ON June 8, during the commencement week at De Pauw University, the corner stone of the new Bowman Memorial Gymnasium was laid with appropriate ceremonies. The building will cost over $100,000.

THE new Honan Biological Institute at University College, Cork, has been completed, as we learn from the *British Medical Journal*, owing to the generosity of the trustees of the estate of the late Miss Honan, and forms a handsome group of buildings, situated near the plant houses which were the gift of the late William Crawford, of Lakelands. The biological laboratory was a small building, much too cramped for the teaching of the students, much less for the research work which has always been a feature of the college. In the new building ample room has been provided for the study of zoology, botany and geology. There are junior and senior zoological and botanical laboratories, as well as research rooms, geological and geographical laboratories, and a large semicircular lecture theater, lit from the roof, and capable of accommodating about 100 students.

THE summer session of the University of California for 1915 by June 30, nine days after the beginning of the six-weeks term, had enrolled 5,420 students, which was more than 2,000 more than on a corresponding date the year before and which was only 52 less than the largest total registration at any one time in the academic colleges and graduate school for the fall or spring sessions excluding students in the professional colleges.

AMONG instructors appointed at the Massachusetts Institute of Technology are: Barnum B. Libby and George Rutledge, mathematics; Walter A. Patrick, theoretical chemistry; Clark S. Robinson and Frederic H. Smyth, inorganic chemistry. Promotions include: Robert P. Bigelow, associate professor of zoology and parasitology; W. Felton Brown, associate professor of freehand drawing; Harold A. Everett, associate professor of naval architecture; Henry B. Phillips, assistant professor of mathematics; Kenneth C. Robinson and Geo. H. Clark, instructors in mechanical engineering; John E. Bird, instructor in mechanical

drawing and descriptive geometry; Leicester F. Hamilton, instructor in analytical chemistry, and Ruth M. Thomas, research associate in organic chemistry.

Dr. Ward J. MacNeal has been appointed director of laboratories of the New York Postgraduate Medical School and Hospital, succeeding Dr. Jonathan Wright, resigned. Dr. Morris Fine has been promoted to adjunct professor of pathologic chemistry; Dr. Richard M. Taylor, to adjunct professor of pathology and Paul A. Schule, to a lectureship of bacteriology.

Mr. R. H. Bogue, for three years instructor in chemistry in the Massachusetts Agricultural College, has accepted a position as assistant professor of agricultural chemistry at the Montana Agricultural College. His place in the Massachusetts College has been filled by the appointment of Paul Serex.

Dr. F. D. Fromme, formerly of the botany department of the Indiana Agricultural Experiment Station, has been appointed to the professorship of plant pathology and bacteriology in the Virginia Polytechnic Institute.

Guy West Wilson, formerly agent, U. S. Laboratory of Forest Pathology, stationed at the Agricultural Experiment Station, New Brunswick, N. J., has been appointed assistant professor of mycology and plant pathology, State University of Iowa, Iowa City, Iowa.

DISCUSSION AND CORRESPONDENCE

NOTE ON THE MERIDIONAL DEVIATION OF A FALLING BODY

Introductory Remarks.—Various definitions have been given for the meridional deviation of a falling body and various potential functions have been assumed in the mathematical determination thereof. It is therefore perfectly natural that the results found by different writers on the subject do not agree. However, when once the equations of motion of the falling body, the definition of the deviation, and the potential function have been fixed, the solution of the problem is unique. In 1911[1] I published a general formula for the meridional deviation which included as special cases the apparently discordant formulæ of several other writers. This was possible because my formula could be broken up into parts which corresponded to different kinds of meridional deviation, and also because it was expressed in terms of the symbol representing the potential function, which symbol, when replaced by particular forms of this function, made it yield the results of the writers who had used these particular forms. In 1913[2] Dr. R. S. Woodward treated the problem using the equations of motion, the definition of the deviation and one of the potential functions which I had used. Therefore he should have obtained the result which I did for that potential function provided my solution was correct. But he got a different result. This lack of agreement was the means of interesting Professor F. R. Moulton in the problem. In June, 1914, Professor Moulton published an article[3] in which he solved the problem treated by Dr. Woodward and his result was the same as mine. Shortly after the appearance of Professor Moulton's article, I published a paper[4] (which, however, was prepared at the same time as Professor Moulton's, and independently of it) showing that Dr. Woodward's methods, when applied to his initial assumptions, should lead to my results. In reply to Professor Moulton's article and my last paper, Dr. Woodward has just published a note[5] in which he states that he did not solve the problem which Professor Moulton and I had solved. The present article is my reply to this note.

Granting that "two different problems have actually been solved," I will show that this is so because Dr. Woodward has not solved the

[1] *Transactions of the American Mathematical Society*, Vol. XII., pp. 335–53, *ibid.*, Vol. XIII., pp. 469–90.

[2] *Astronomical Journal* (Nos. 651–52), August 4, 1913.

[3] "The Deviations of Falling Bodies," *Annals of Mathematics* (Second Series), Vol. 15, pp. 184–94, June, 1914.

[4] "Deviations of Falling Bodies," *Astronomical Journal*, Nos. 670–72, pp. 177–201, January 22, 1915.

[5] "Note on the Orbits of Freely Falling Bodies," Science, New Series, Vol. XLI., No. 1057, pp. 492–95, April 2, 1915.

problem which he originally proposed. The solution of the problem which he now states in his note that he has solved corresponds to a meridional deviation different from that originally defined. This deviation is of the form $Ah + Bh^2$, while that originally defined was of the form Ch^2, in which h is the height of fall and A, B, C are constants. I will also show that a formula for this new meridional deviation may be obtained without integrating the equations of motion at all, and that this formula yields a result differing but slightly from the result given by Dr. Woodward, but given by him for the deviation originally defined. In this article I will also reply to certain criticisms made by Dr. Woodward concerning my work.

1. In the sixth paragraph of his note[6] Dr. Woodward says:

> Now, to account for the discrepancy in question, namely, our differing values for the meridional deviation of the falling body, it is only essential to observe that two different surfaces of reference have been used. Profesors Moulton and Roever have referred the motion to a geoid specified by a certain approximate potential function, while I have referred the same motion to Clarke's spheroid of revolution (of 1866), which is determined by certain axes (a, b) dependent on geodetic measurements.

In reply to this statement I should like to say that in order to determine the path (orbit) of the falling body a potential function is needed; a surface of reference is not enough. When once the potential function is chosen the geoid (or level surface) is determined. That the geoid, and not the spheroid, was originally contemplated by Dr. Woodward as the surface of reference, appears from the statement made below equations (2) of his paper in the *Astronomical Journal* (Nos. 651–52). For, of the points P_0 and P_1 from which, respectively, the body is let fall and the deviations measured, he says:

> It is important to specify how this point P_1 is located with reference to the initial point P_0. Imagine a basin of mercury at the point P_1. The surface of the mercury will be the level, or equipotential (or horizontal) surface through this point; and if it is located as here assumed the line joining the two points P_0 and P_1 will be normal to the surface of the mercury.

Now, the surface of the mercury is surely a portion of the geoid and *not* of the spheroid. The position of the point P_1 besides depending on that of P_0, depends on the potential function, and, furthermore, on the same potential function as that which is used in the differential equations of motion of the path of the falling body. Dr. Woodward now states that he used for his surface of reference the spheroid (of Clarke) instead of the geoid. If these two surfaces differ ever so slightly from one another—and they do differ according to equations (2) and (3) of his note[7]—the quantities which are determined by using the spheroid for reference are not the same as the quantities η, ξ (measured from P_1) which he originally defined as the easterly and meridional deviations of the falling body. Therefore, the problem which he now states that he has solved is not the one which he originally proposed.

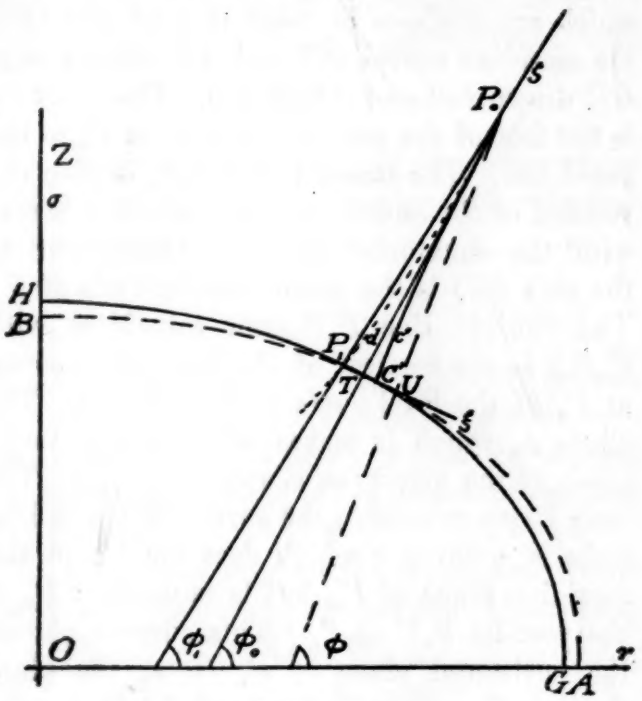


FIG. 1.

[6] SCIENCE, No. 1057, pp. 493.

[7] SCIENCE, No. 1057.

2. For the sake of simplicity let us assume (as Dr. Woodward did before he got very far into his solution) that the distribution of the earth's gravitating matter is such as to make the potential function independent of the longitude (*i. e.*, correspond to a *distribution of revolution*). Let P_0 denote the point (fixed with respect to the earth) from which the body falls. In Fig. 1 the plane of the drawing is assumed to be the meridian plane of P_0. This plane contains the axis of rotation OZ, and cuts from the geoid and the spheroid (both of which are surfaces of revolution of axis OZ) the meridian curves GH and AB, respectively, GH drawn full and AB dashed. The point P_1 is the foot of the perpendicular from P_0 to the geoid GH. The straight line P_1P_0 is then the vertical of PA and the angle ϕ, which it makes with the equatorial plane (perpendicular to the axis OZ) is the astronomic latitude of P_1. The straight line P_0T (not coincident with P_0P_1) is the vertical of P_0 (*i. e.*, the normal at P_0 of the level surface through P_0). The angle ϕ_0 which it makes with the equatorial plane is the astronomic latitude of P_0.[8] The path (with respect to the earth) of the falling body is a curve c which does not lie in the meridian plane of P_0, but is tangent at P_0 to the vertical P_0T of P_0. This curve c pierces the horizontal plane of P_1 (*i. e.*, the plane through P_1 perpendicular to P_1P_0) in a point C. Let us denote by c' and C' the orthographic projections of c and C, respectively, on the meridian plane of P_0. Then c' is also tangent to P_0T at P_0. According to the definitions originally adopted by Dr. Woodward,

$C'C$ is the easterly deviation of the falling body,
P_1C' is the meridional deviation of the falling body.

He now says, however, that he referred the motion of the falling body to the spheroid (AB, Fig. 1). By this he must mean that he measures the deviation of the falling body from the foot U of the normal drawn from P_0 to the spheroid. The angle ϕ which this normal (shown in Fig. 1 by the dashed line P_0U) makes with the equatorial plane is called the geodetic latitude of U. In other words, the statement that the spheroid is his surface of reference implies that UC' is the meridional deviation of the falling body. That this is the implication is also borne out by the fact that the value of this deviation agrees with the value which Dr. Woodward actually found. In order to show this let us first observe that

$$UC' = UT + TC', \tag{1}$$

the positive sense of each of these quantities being taken toward the equator. If ϕ and ϕ_0 be expressed in radians,

$$UT = (\phi_0 - \phi)h, \tag{2}$$

where $h = P_1P_0$ is the height of fall. Since the curve c' is tangent to P_0T at P_0, and has no cusp there,[9]

$$TC' = \tfrac{1}{2}(1/\rho_0)h^2 + \text{higher powers of } h,^{10} \tag{3}$$

where ρ_0 is the radius of curvature of c' at P_0. By equations (2) and (3) of Dr. Woodward's note,[11] $\phi - \phi_0 = 12'' \sin 2\phi$, and hence in circular measure

$$\phi - \phi_0 = .00006 \sin 2\phi. \tag{4}$$

Hence for the data

$$h = 49024 \text{ cm.}, \quad \phi = 45°, \tag{5}$$

assumed in his example in the *Astronomical Journal* (Nos. 651–652)

$$UT = -2.94 \text{ cm.}$$

[8] The difference between ϕ_0 and ϕ_1 is given by the formula

$$\phi_0 - \phi_1 = \frac{-(\partial g/\partial \xi)_1}{g_1} h + \text{higher powers in } h,$$

where h is the distance of P_0 above P_1, g_1 is the value of the acceleration due to weight at P_1, and $(\partial g/\partial \xi)_1$ is the value, at P_1, of the derivative of g with respect to ξ, where ξ represents distance measured to the south at P_1. For the potential function used by Dr. Woodward (*Astronomical Journal*, Nos. 651–52),

$$\frac{-(\partial g/\partial \xi)_1}{g_1} = 8.3 \times 10^{-12} \sin 2\phi_1.$$

[9] The curve c has a cusp at P_0 as has also its projection on a plane perpendicular to the meridian plane of P_0.

[10] See "Introduction to Infinite Series," by Osgood, p. 39.

[11] Science, No. 1057.

For the same data and for the potential function used by Dr. Woodward,[12]

$$TC' = .0010 \text{ cm.}$$

Therefore

$$UC' = UT + TC' = -2.94.$$

This result agrees very well with the value $\xi = -3.03$ obtained by Dr. Woodward for his originally defined meridional deviation. Thus I have shown that for the meridional deviation implied by the statement that the spheroid instead of the geoid is the surface of reference, it is possible to find a formula, namely

$$UC' = -(\phi - \phi_0) \sin 2\phi \cdot h, \tag{6}$$

without integrating the equations of motion, and that, for the data given by equations (2) and (3) of Dr. Woodward's note, this formula yields values for the deviation UC' which do not differ much from those obtained by Dr. Woodward for his originally defined meridional deviation.

3. We have just seen that the expression (formula 6) for the newly defined meridional deviation UC' begins with the first power of h. Let us now show, with the aid of Fig. 1, that the originally defined meridional deviation P_1C' begins with the second power of h. For this purpose let us think of a series of level surfaces between the geoid GH and the level surface of P_0. The locus of the feet of the perpendiculars from P_0 to these level surfaces is a curve d passing, necessarily, through the points P_0 and P_1 and tangent at P_0 to the vertical P_0T of P_0 (see dotted curve in Fig. 1). Since the curve d is tangent to P_0T at P_0, we have for a reason given above,

$$P_1T = \tfrac{1}{2}(1/\rho_d)h^2 + \text{higher powers of } h, \tag{7}$$

where ρ_d is the radius of curvature of the curve d at the point P_0. It is further evident from Fig. 1, that

$$P_1C' = P_1T + TC', \tag{8}$$

the positive sense of each of these quantities being taken toward the equator. By relations (3), (7) and (8)

$$P_1C' = \frac{1}{2}\left(\frac{1}{\rho_d} + \frac{1}{\rho_0}\right)h^2 + \text{higher powers of } h.^{13} \tag{9}$$

Hence we see that while the originally defined meridional deviation P_1C' begins with the second power of h, the newly, implicitly, defined meridional deviation UC' begins with the first power of h.

4. In commenting on my work, Dr. Woodward, after speaking of a certain assumption,

[12] The quantity TC' is the negative of the quantity which I denoted by η_1 in my first paper (*Transactions of the American Mathematical Society*, Vol. XII., No. 3, pp. 335–53). It is the quantity which Comte De Sparre used for his meridional deviation of a falling body. I have shown this quantity to be expressible by the formula

$$TC' = \left\{2\omega^2 \sin 2\phi_0 + \left(\frac{\partial g}{\partial \xi}\right)_0\right\}\frac{h^2}{6g_0},$$

where h and ϕ_0 have the meanings given above, ω is the angular velocity of the earth's rotation, and g_0 and $(\partial g/\partial \xi)_0$, are the values which the acceleration g due to weight and the derivative of g with respect to ξ have at the point P_0, ξ representing distance measured to the south. For the potential function used by Dr. Woodward (*Astronomical Journal*, Nos. 651–52), $(\partial g/\partial \xi)_0 = -8.14 \times 10^{-9}$ sin 2 ϕ_0 and hence, since $\omega^2 = 5.3173 \times 10^{-9}$ we have for this potential function

$$TC' = 2.49 \times 10^{-9} \sin 2\phi_0 \cdot \frac{h^2}{6g_0},$$

which for the data (5) yields

$$TC' = +.0010 \text{ cm.}$$

[13] It is not difficult to show that

$$P_1T = -\left(\frac{\partial g}{\partial \xi}\right)_0 \cdot \frac{h^2}{g_0},$$

where the terms have the same meaning as in the preceding foot-note. Consequently

$$P_1C' = P_1T + TC' = \left\{2\omega^2 \sin 2\phi_0 - 5\left(\frac{\partial g}{\partial \xi}\right)_0\right\} \cdot \frac{h^2}{6g_0}.$$

This formula I proved for the first time in the *Transactions of the American Mathematical Society*, Vol. XII., No. 3, pp. 335–53. See also Vol. XIII., pp. 469–90, *Astronomical Journal*, Nos. 670–72 and *Bulletin of the American Mathematical Society*, 2d series, Vol. XXI., No. 9, pp. 444–62. For the potential function used by Dr. Woodward,

$$(\partial g/\partial \xi)_0 = -8.14 \times 10^{-9} \sin 2\phi_0,$$

whence, for that potential function

$$P_1C' = 51.33 \times 10^{-9} \sin 2\phi_0 \; h^2/6g_0,$$

which for the data (5) gives

$$P_1C' = +.021 \text{ cm.}$$

now abandoned, which he made concerning my earlier paper, says:

> This assumption was supported by uncertainty as to meaning and by lack of homogeneity of his expression for the potential function introduced on page 342 of his first paper; and still more by his identification of astronomic with geocentric latitude (on p. 339, same paper) by means of the loose phrase "with sufficient approximation." A similar lack of "accuracy and precision" will be found in several parts of his latest paper cited above. See, for example, his equations (*j*), wherein he confounds geocentric with reduced latitude; also p. 199, where he identifies his equations (38) and (41) with my equation (26) and makes with respect to them the surprising statement, "it is, of course, evident that this function corresponds to some distribution of revolution" in the earth's mass.

I shall reply first to the criticism concerning the "identification of astronomic with geocentric latitude." After having derived (in my first paper) a general formula for the meridional deviation of a falling body, I assigned various particular forms to the potential function and thus obtained the formulæ for the meridional deviations corresponding to these particular potential functions. Some of these potential functions were expressed in terms of astronomic latitude, and others in terms of geocentric. Consequently, the same thing was true of the corresponding formulæ for the meridional deviation. For instance, the formula of Gauss was expressed in terms of astronomic latitude and several others were expressed in terms of geocentric latitude. In order to compare the magnitudes given by the special formulæ I replaced, in the formula of Gauss, the symbol representing astronomic latitude by that representing geocentric, and in so doing I used the expression "with sufficient approximation" for which I am now criticized. It is of course evident that by this procedure a slight error was made in the formula of Gauss *after* its rigorous form had been derived. But none of the other work was thereby affected, the derivation of the general formula as well as that of each of the special formulæ being strictly rigorous. Concerning the criticism about my equations (*j*) I wish to say that the parameter ψ may be regarded as a geocentric latitude, since it is measured at the center of the spheroid and from the equatorial plane. I did not say that it was the geocentric latitude of the point (τ, σ). However, it would have been well to mention that it is called the reduced latitude of the point (τ, σ). But even if the reader interprets it as the geocentric latitude of the point (τ, σ), the argument in which it is used will not thereby be vitiated. For, as I pointed out, the relation (*l*) in which it is used is approximate, the relation (*n*) being the exact relation approximated. Now, the error made in using relation (*l*) instead of relation (*n*) is twice as great as the error made in relation (*l*) by calling ψ the geocentric instead of the reduced latitude of the point (τ, σ). As regards the "surprising statement," I should like to point out that on page 192[14] I defined a distribution of revolution as one for which $\partial V/\partial\lambda \equiv 0$, and surely my function (38) satisfies this condition since it does not contain the longitude λ. Then I was very particular to say—in the last foot-note on page 199—that for the assumption $B = A$ made by Dr. Woodward in his relations (31), his potential function (26) is the same as my potential function (38). Concerning the potential function introduced on page 342 of my first paper, I stated that it had been taken from Poincaré, "Figures d'Equilibre d'une Masse Fluide" (1902), Chapt. V. Following Poincaré, I used the symbol M where Dr. Woodward used the symbol M_K. In other words, I suppressed the gravitation constant. But it was easy to see from the expressions and values of the constants that no error had been made in so doing.

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Vegetative Regeneration of Alfalfa

When growing alfalfa plants in the greenhouse, for infection experiments with the crown-gall of alfalfa (*Urophlyctis alfalfæ*), the writer found it desirable to clip the shoots at intervals in order to secure a multiplication of the adventitious buds from the crown.

[14] *Astronomical Journal*, Nos. 670–72.

Some of the portions of the leaves and stems clipped from the plants dropped upon the soil of the pots and were allowed to remain there. Some days later it was found that a number of these fragments had put out roots from the cut surfaces and were developing into healthy shoots. As the plant under consideration is of great economic importance, a further experiment was tried in order to see if the regeneration of shoots from cut fragments of alfalfa is easily induced. A handful of fragments cut from an entirely different group of alfalfa plants was scattered loosely over the surface of a pot of well-watered soil. The fragments were watered from day to day, care being taken to avoid altering their positions. After a week it was found that fragments of several descriptions had rooted firmly and were developing into healthy shoots. The regenerating fragments included portions of stems, portions of petioles, petioles with blades attached, leaflets without petioles attached, and even small portions of the leaf blade.

So far as the writer has been able to learn, multiplication by this vegetative method has not been reported of alfalfa previous to this time. Under favorable conditions, such regeneration might assume considerable importance in the field. Especially suggestive is the possibility of strengthening a stand in an irrigated district by an early cutting followed by free watering. The cut portions might be left where they fall, or collected and scattered over areas where the stand is thin.

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QUOTATIONS

THE ORGANIZATION OF SCIENCE IN GREAT BRITAIN

AT last, on all sides, it is being recognized that we should organize our scientific resources. Had the suggestion which I made to this effect on January 20 been acted on—that is to say, if the Royal Society had grouped the whole body of its fellows (mainly according to subjects) in grand committees and set these to work—we should have been many months in advance of our present position, and not a little might have been done to apply science to the numerous problems which are only now being hinted at in public. In view of our scientific conservatism, it is impossible to blame the uninstructed masses and difficult to find much fault even with our rulers.

It is well known that the men who are versed in the chemistry and properties of explosive materials and who might, during all these months, have rendered the greatest service in perfecting their production and in improving them have not been consulted. One of the two men to whom the service ammunition of all the armies of to-day is due is still with us and an active scientific worker; in no other country would it have been possible that such a man should not have been called into consultation. Many of us might have been of assistance if only as foremen in works—technical foremen have been badly needed.

It is imperative that the strongest body of technical opinion that we can bring together should be behind the War Office and the authority that is charged with the supply of explosives. It is to be hoped that Mr. Lloyd George is now alive to this need and of the deadly peril in which we stand if it be neglected. The suggestion has been made that Lord Haldane should be invited to preside over a committee of concentrated scientific intellect to deal with war problems. But Lord Haldane, as a lawyer, would be entirely out of place as chairman of such a body; it must be in expert hands to be of service. The government is not competent to select the members of such a commission. I believe the Royal Society to be the only competent advisory body under the circumstances—it is our scientific House of Peers, and if it can not either itself furnish sufficient competent men or provide them from the junior ranks of science, the sooner it is declared defunct the better.

I would again urge that the society be organized forthwith as a whole; not only is this the only way of eliminating personal differences, but it is the only way of getting at the ideas latent in our scientific community. No half-dozen or so persons, at the present time, have the right to assume that they can do all that is required in any branch of science; no

small number have the right to push their colleagues aside and say we alone will serve the country.

Mr. Wells asks for inventions; but inventions are only made by those who are aware of the requirements; it is often possible to devise a means to an end when the end is known; but those who might be of use are kept in the dark, very many of us are not allowed to know and to help. Professor Fleming has stated his experience, in the all-important letter which you have published; his authority on matters of wireless telegraphy and electrical engineering generally is indeed properly described, in Lord Curzon's words, as "high, not only in the estimation of this country, but in that of the whole world." I am in the same position as he is. Though I have fifty years' experience as a chemist, particularly in connection with the materials now being used in the manufacture of explosives and of natural and artificial organic products, I have never once been consulted; the only request for my assistance that I have received, since the outbreak of the war, came from a German gentleman long naturalized as a British subject. No doubt, I am properly regarded as merely a retired professor, but I know highly competent younger men among those trained by me who are equally unutilized.

Sir Joseph Larmor pointed out in your issue of March 29 that the country has no use for chemists. Yet we read daily in the papers that the chemist is now the people's darling in Germany, and that the war is a war of chemists; we know that it will be in industry when fighting is over. But in a country which is dominated by the lawyer-politician, in which, to use Matthew Arnold's expression, "the idea of science" is unknown, it can not well be otherwise. We shall continue to muddle along until, having reformed Oxford, we have changed our schoolmasters and the idea of science is abroad; it is perhaps fortunate that it is fast being hammered into us by high explosive shell.

As a fellow of all but forty years' standing, let me say in conclusion that, in my opinion, unless the Royal Society be organized as a whole forthwith in the service of the state, as well as provided with an efficient active executive in full sympathy with the situation, we shall deservedly sink into insignificance, because the peers of science will have shown themselves to be collectively impotent and without due sense of their public responsibilities.—*Henry E. Armstrong, in the London Times.*

SCIENTIFIC BOOKS

Modern Instruments and Methods of Calculation. A hand-book of the Napier Tercentenary Exhibition. Edited by E. M. Horsburgh, with the cooperation of others. The Macmillan Company, New York, 1914. Pp. viii + 344. Price $1.90 net.

It is very seldom that an international congress or a celebration on the occasion of any kind of academic anniversary offers the opportunity for the publication of anything more elaborate than a volume of memoirs. Such volumes are generally well worth the effort, but there is rarely anything unique in the plan, and the publications often serve as a tomb in which various worthy articles are consigned to oblivion. The Napier Tercentenary, however, offered an opportunity for something radically different in the way of memorial volumes. To be sure there is the collection of essays, soon to appear; but the committee in charge of the work hit upon the idea of an exhibition of all sorts of tables and calculating machines, and fortunately found a man well trained in the field of calculation, sympathetic with the historical development of the subject, and skilful in setting forth the description of material, and to this man they entrusted the task of preparing a volume that is quite unique in the history of such congresses.

Mr. Horsburgh had in charge the arrangement of the interesting exhibition in the university, and to some extent this work is a catalogue of the material displayed at that time. It is much more than this, however, since it includes a series of valuable essays describing the tables, the calculating machines of various types, and those instruments which, together with models and other material, enter into the equipment of a modern mathematical laboratory.

Among the special essays may be mentioned the following: "Napier and the Invention of Logarithms," by Professor Gibson, of Glasgow, perhaps the best essay which has appeared upon the great Scotch mathematician; "Notes on the Special Development of Calculating Ability," by Dr. W. G. Smith, an excellent summary of the history and psychology of the subject; "Calculating Machines," by F. J. W. Whipple, a description of the standard engines of calculation written from the standpoint of the practical computer and elaborating the descriptive catalogue prepared for the Fifth International Congress of Mathematicians in 1912; "The Calculating Machine of the East: the Abacus," by Dr. C. G. Knott, the efficient secretary of the Royal Society of Edinburgh, and one of the prime movers in the Napier Celebration—a classical essay upon the subject and one which has been out of print for nearly thirty years; "The Slide Rule," by Dr. G. D. C. Stokes, a historical review of the various types of these instruments; "Integraphs," by Charles Tweedie; "Integrometers," "Planimeters" and "Harmonic Analysis," by Dr. G. A. Carse and Mr. J. Urquhart; "Integrating Machines in Naval Architecture," by A. M. Robb; "A Differentiating Machine," by Dr. J. Erskine Murray; "Tide-predicting Machines," by Edward Roberts; "A Mechanical Aid in Periodgram Work," "A Mathematical Description of Conics" and "The Instrumental Solution of Numerical Equations," by D. Gibb; "Ruled Papers," by E. M. Horsburgh; "Collinear-point Nomograms," by Professor D'Ocagne; "Mathematical Models," by Professor Crum Brown; and "Closed Linkages," by Colonel R. L. Hippisley. Besides these essays, numerous shorter notes appear, all of them written by experts in their fields.

A catalogue of the mathematical portraits in the collection of W. W. Rouse Ball, the well-known writer on the history of mathematics, will prove of value to all collectors.

It is impossible in the space at our disposal to speak in detail of any of the essays, several of them profusely illustrated and all of an authoritative nature. Suffice it to say that the book should be in every mathematical library and workshop as being the most valuable treatise of its kind that we have in English, and, indeed, about the only one in any language except such as is found in the articles in the German encyclopædia.

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Die Elemente der Entwicklungslehre des Menschen und der Wirbeltiere. Anleitung und Repetitorium für Studierende und Aerzte. VON OSCAR HERTWIG. 5te Auflage. Jena, Gustav Fischer, 1915. Pp. x + 464. 416 figs.

This work, already well known through former editions, must be regarded as among the *opera minora* of its distinguished author. It is professedly a utilitarian text-book, and discussions not adapted to "comprehensive brief presentation, suitable for a text-book," have been omitted. For further information, Professor Hertwig appropriately refers the student to his "Lehrbuch," ninth edition, his "Allgemeine Biologie," fourth edition, and the imposing "Handbuch der Entwickelungsgeschichte der Wirbeltiere," which he edited and to which he contributed important chapters.

The fourth edition of the "Elements" was published in 1910 and the present volume, although reset throughout, contains only minor changes—chiefly such as are designed to make the book more useful to students of medicine. Except that Hochstetter's series of diagrams of the development of the vena cava inferior has been replaced by Kollmann's drawings of the same subject, all the figures in the last edition have been republished. To these are added sixteen others, eight of which show young human embryos and their adnexa, three illustrate cleft palate, two pertain to the vascular system, and the remaining three represent the *tunica vasculosa lentis,* the human branchial region and one of Keibel's models of the urogenital tract, respectively. None of the new figures is original, for Professor Hertwig is not of those who, on seeing a good drawing, make another much like it to be called their own. He prefers to present to the students a

wide selection of familiar figures, which have served, quite as much as the text which accompanied them, to advance the science of embryology.

Chapter 1 begins with the following interesting statement:

> In the seventeenth and eighteenth centuries, the most confused ideas of the nature of the process of animal development still prevailed. Influenced involuntarily by the religious dogmas of their time, the greatest anatomists and physiologists, with few exceptions, were of the opinion that the germ was merely a much reduced miniature of the later fully developed condition.

Was not the idea of preformation a direct result of observation and reflection upon natural phenomena, quite apart from "religious dogmas"? This indeed appears to be true, and the comment of a distinguished theologian upon Professor Hertwig's statement is as follows:

> Let the men of science assume the parentage of their own *homunculi!* I certainly know of no dogma that the germ was a miniature of the man that was to be, nor even a doctrine which could be understood or misunderstood in that sense.

Thus it appears that this introduction needs explanation or revision. The entire work might profitably be expanded at many points, notably so as to include some account of the development of the lymphatic system. But the title of the book disarms such criticism; the *elements* are admirably presented in a text which is simple, direct and substantial throughout.

Frederic T. Lewis

SPECIAL ARTICLES

Electrical Density and Absorption of β-Rays

There have been a number of attempts to relate the absorption coefficients of various bodies for the β-radiation to some physical properties of the absorbing substance. In 1895, Lenard determined the absorption coefficients for cathode rays of a number of bodies, and concluded that the absorption varied approximately as the density, though his values of μ/D differed by more than one hundred per cent. Similar results were obtained for the absorption of β-rays from radium and uranium by Strutt and by Rutherford.

The first to determine the absorption coefficient of a considerable number of elements for the β-rays was Crowther, in 1906.[1] Crowther found the ratio of the absorption coefficient to the density of the elements to increase with the atomic weight of the absorbing element, but apparently not according to any regular law. Crowther, however, plotted the ratio of the absorption coefficient to the density of 31 elements against their respective atomic weights, and obtained a number of points which he divided into groups having no apparent physical or chemical relationships, and showed that the elements in each of these groups could be joined by curves having some resemblance to one another.

It is the purpose of this paper to show that the absorption coefficient of the elements for β-rays is dependent rather upon the electrical density of the absorbing agent than upon its mass density.

It has been shown in a number of papers by the present writer how the electrical charges of the dissociated ions in an electrolytic solution may be calculated from their masses and their migration velocities in an electric field. Knowing these charges and the volume occupied by a gram-atom of an element in its solid state, we may calculate the electric density of the element by dividing its atomic charge by its atomic volume. It is the electric density calculated in this way which seems to be an important determining factor in the absorption of the β-radiation.

Unfortunately, only a small number of atoms have had their charges calculated in this way, but eleven of these are included in the list of thirty-one elements whose absorption coefficients for the β-rays of uranium were determined by Crowther.

In the table below column ii contains the values of λ/ρ for these eleven elements taken

[1] *Phil. Mag.*, 12, p. 379 (1906).

i	ii	iii	iv	v
Element	λ/ρ	λ	D_e	λ/D_e
Na.....	4.95	4.8	.66	7.28
Mg	5.1	8.9	1.25	7.12
K	6.53	5.7	.87	6.55
Ca.....	6.47	10.0	1.28	7.8
Cu.....	6.8	60.6	6.58	9.2
Zn.....	6.95	49.4	5.23	9.45
Sr.....	8.5	21.6	2.04	10.6
Ag	8.3	87.2	8.97	9.7
I	10.8	53.5	5.17	10.3
Ba.....	8.8	32.8	3.27	10.0
Pb.....	10.8	123.0	11.0	11.2

from Crowther's table, and in column iii are given the corresponding values of λ calculated by multiplying λ/ρ by the densities in the solid form of the corresponding elements. Column iv contains the electrical density, D_e, calculated by dividing the atomic charges of the elements by their respective atomic volumes in the solid state, and column v contains values λ/D_e. It will be seen that the variations from a mean value are less in column v than in column ii. This is also shown graphically in Fig. 1, where the mass densities and the electrical densities are plotted against the absorption coefficient. The points representing the relations of the electrical densities to the corresponding absorption coefficients are indicated by circles, while the corresponding points for mass densities are indicated by crosses. It will be seen that the circles lie more nearly on a smooth curve than do the crosses.

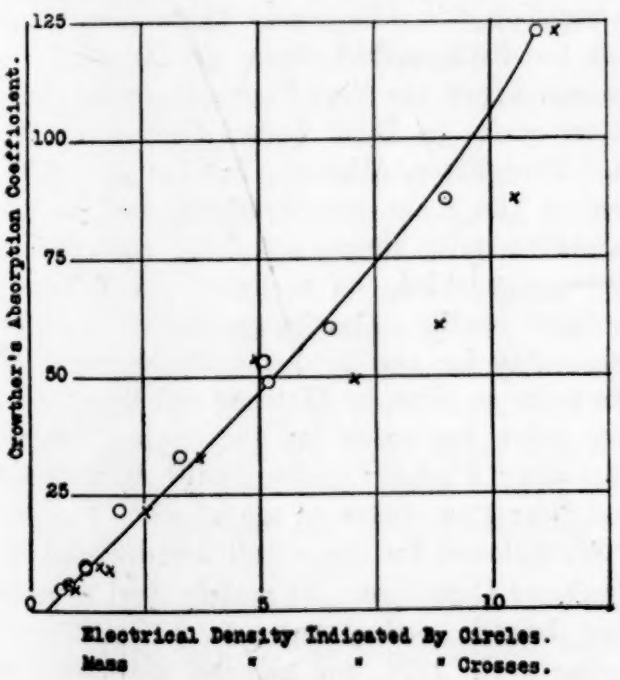

FIG. 1.

FERNARDO SANFORD
STANFORD UNIVERSITY, CALIF.

EVIDENCE PROVING THAT THE BELLY RIVER BEDS OF ALBERTA ARE EQUIVALENT WITH THE JUDITH RIVER BEDS OF MONTANA

ON the twenty-fourth of last July a paper of mine appeared in SCIENCE in which I took the ground that the Dog Creek Beds of Montana were equivalent to the Edmonton Beds of Alberta and that the Cow Island Beds of Montana should be correlated with the Belly River series of Alberta, with the Fort Pierre deposits between. I thus took the early views of Professor E. D. Cope that the Judith River Beds were on top of the Pierre. Judging from memory, I was unable to believe that the Fort Pierre was on top of the Judith River formation. I concluded, therefore, that the sequence of rocks in Montana would be the same as those in Alberta, where the Belly River series is below the Pierre, and the Edmonton is above.

Last July, however, with Mr. D. B. Dowling, a senior geologist of the Geological Survey of Canada, and my son, Charles M., who took most of the photographs, I spent ten days in the Judith River country, going over the same region I walked over in 1876 as Professor Cope's assistant. I was soon forced by incontestable evidence to change my opinions, and accept without reservations the conclusions of Hatcher and Stanton in their fine work on the "Geology and Paleontology of the Judith River Beds." We actually added to the weight of the evidence they had gathered by the discovery, as I believe for the first time, of some sixty feet of Bear Paw shales on top of the Judith River Beds, on the head of Taffy Creek, an easterly fork of Dog Creek. Also heavy masses on top on the south side of the river near Cow Island. Mr. R. G. McConnell, deputy minister and director of the Geological Survey of Canada, has kindly allowed me to present this paper in a private capacity, Mr. Dowling being the mouthpiece of the Geolog-

ical Survey of Canada on this exploration. It was seen how easily the early explorers could have misunderstood the arrangement of the strata, as they have been tilted in all directions and at all angles. In one place great masses of the rocks, often acres in extent, have been lifted higher than newer rocks, or dropped below them. Then the stratigraphical characters of the Claggett shales resemble those of the Pierre so closely it is difficult at first view to tell them apart.

Last July we followed up the valley of Dog Creek, on the road to a sheep ranch on the prairie. A couple of miles above where the creek enters the canyon we came to a strip of Claggett shales lifted up besides the Eagle Sandstone and Judith River Beds, the shale disintegrating into rather steep slopes over which our road lay. We climbed the steep ascent to the ridge, some 600 feet above the Missouri River and followed the divide between the Badlands of the Missouri and of Dog Creek. We camped on Taffy Creek, an eastern branch of Dog Creek. We made a very thorough study of this region, making large collections of invertebrates from all the horizons, and secured *Myledaphus* and sharks' teeth from the Eagle Sandstones, which, with the Claggett shales, I am informed, forms the base of the Belly River series of Canada.

On the south side of Taffy Creek below a large timbered Hog Back, I found a locality in the gray sandstone of the Judith River Beds that may possibly be the type locality from which we got collections on that memorable expedition in 1876, when we found the first horned dinosaurs of the United States, a "blow out" as it is called in the west, where quite an area in a bed of sandstone had been denuded, I found quantities of the teeth of horned, plated, duck-billed and carnivorous dinosaurs and of *Myledaphus bipartitus* Cope, scales of ganoid fishes, vertebræ of *Champsosaurus* and many fragments of turtle shells (*Trionx*, etc.), and what delighted me more, a complete footed ischium with most of the illium and pubis of one individual of a hooded trachodont, evidently Lambe's *Stephanosaurus marginatus*, from the Belly River series of Red Deer River, Alberta. It was difficult for me not to believe I was in a Red Deer bone-bed, as the same material was strewn around here in Montana. In the Edmonton, however, the bones have the appearance of having once been flotsam along a sea shore at the limit of high tide. I only found a couple of fragments of turtle shells there, while they are very abundant in this bone-bed on Taffy Creek. Everywhere in this region are two veins of coal, on top of the Judith River Beds and immediately below the Bear Paw shales. Above each vein is an oyster bed, often three or four feet thick. In the Bear Paw shales south of camp, with the aid of a sheepherder, Mr. Dowling found a fine new Mosasaur, evidently a *Clidastes*, as the chevrons are anchylosed to the centra of the vertebræ and the end of the tail is expanded into a fin. We secured the mandibles with teeth, a lot of dorsal vertebræ, and nearly 15 feet of the tail. We also collected some fine Ammonites and Baculites as well as a couple of specimens of a Plesiosaur, resembling *Cimoliosaurus*. These fossils can not be distinguished from similar ones we procured from the Fort Pierre above the Belly River series in Dead Lodge Canyon on the Red Deer River, Alberta. But for the uplifting of the rocks the stratigraphical record would be quite simple. A little observation, however, enabled one to detect the different horizons readily. On the ground it would be impossible for one to doubt the sequence of the rocks as given by Hatcher and Stanton in the order beginning at the bottom, Eagle Sandstone, Claggett shales, Judith River Beds and Bear Paw shales on top of all.

We followed the same trail first traveled by Professor Cope down the prairie level to near Cow Island, getting water at "Lone Tree" spring as in 1876, and camped near our old camp, on the Missouri River. We found the Bear Paw shales on top of the Judith River Beds, on the south side of the river three miles below Cow Island. The only difference between the formation here and Dog Creek is the absence of the Eagle Sandstones and Claggett shales. The sculpture and lithological characters of the bad lands approached more

nearly those of the Dead Lodge Canyon on the Red Deer River. Two things have especially impressed me: First, the close resemblance between the Judith River Beds and the Belly River series in the Dead Lodge Canyon where the Fort Pierre on top and Belly River series below are nearly 500 feet thick. Towards its lower end a sandstone like the Eagle is exposed. The second is the finding of a footed ischium of a trachodont in the same bed from which the type of *Trachodon mirabilis,* of Leidy, was discovered, the same teeth to which he gave the name lying around the ischium. That evidently belongs to Lambe's *Stephanosaurus marginatus:* a crested trachodont. My party has already discovered three trachodonts in the Belly River series, two with footed ischia and one Lambe's *Gryposaurus notabilis,* has an uncrested head. We have only found among our forty tons of fossil dinosaurs collected there a single species of *Trachodon.* The one we mounted from the Edmonton is certainly one. Is it possible, then, that Leidy's *Trachodon mirabilis* was a crested duck-bill? This is a question impossible of solution, as the type tooth might have come from one of three or four of the Trachodonts of the Belly River series. Then the use by Marsh of two horn cores to found the genus *Ceratops* on and the family *Ceratopsia* rests on a shaky foundation along with Cope's *Monoclonius.* These horns of Marsh might have come from any of the horned dinosaurs of that time except *Centrosaurus,* and in spite of the splendid and complete skulls of horned dinosaurs we have secured from the Belly River series we know nothing of *Monoclonius* except what little, if anything, can be learned from the types.

Then the richness of the fauna in genera and species both of duck-billed, plated, horned and carnivorous dinosaurs, was at high tide during Belly River time. The formation, therefore, must have covered a wide area, and it is not surprising to know that Brown got a *Gryposaurus* skull in New Mexico. A thorough exploration of the beds in Montana will doubtless yield rich returns. It is also interesting to note that I got a plated dinosaur some years ago in the Niobrara Chalk of Kansas, described by Weiland, doubtless a near relative of Lambe's *Europlocephalus* from the Red Deer River. Evidently then the Cretaceous dinosaurs continued to live and thrive through Cretaceous time in the west, but few bones found lodgment in the ocean sediment of thousands of feet of Dakota, Fort Benton, Niobrara, Fort Pierre and Fox Hills groups. It appears evident, too, that the life of the Pierre ocean was continuous with the Belly River, whose shores were only raised a few feet above tide water. Many Plesiosaurs found entrance to the freshwater lakes and mingled their bones with the reptilian fauna. Hatcher himself once told me he believed all the beds of the Judith River region were Pierre from top to bottom, though I suppose land, fresh water and marine beds will always be known by different names.

CHARLES H. STERNBERG

THE TRAVERTINE RECORD OF BLAKE SEA

AN outlying mass of fragmental granite projects from a spur of the Santa Rosa Mountains into the Cahuilla basin in southeastern California, the crest of the rocks rising above the ancient shore line of Blake Sea, which filled the basin to a level, something above that of present high tide in the Gulf of California.[1]

This cape is designated as "Travertine Point" in our publications, as the surface of the granite boulders is covered to a varying depth with dendritic and lithoid tufa.[2] Some marks and figures presumably carved by Indians in the travertine have long been known and were seen by us on our first visit to the place in 1906. In the continuation of our work on the Salton Sea it was realized that these figures might possibly yield some evidence as to the duration, and variations in level of the ancient Blake Sea, and of the smaller modern Salton Lake.

A visit to the formation was accordingly

[1] See Plate 1, "The Salton Sea," MacDougal, *et al.,* Publ. Carnegie Institution of Washington, No. 193, 1914.

[2] See Jones, J. C., "The Geologic History of Lake Lahontan," SCIENCE, XL., p. 827, 1914.

made in March, 1915, and a careful inspection showed that the number of carvings on the rock was very large, and that some have been coated over to such depth that they may be made out only in the most favorable illumination or shading. Others show as deep furrows with weathered surfaces, visible at a hundred yards or more, while none of recent origin have yet been found.

A slice of the travertine extending across four lines of a complex pictograph and down to the granite base was cut out, and the surfaces of the sample are now being polished and prepared for critical examination. Some time may be required to determine the degree of uniformity, or of differentiation into layers which might indicate more than one period of deposition, and a series of such samples may be necessary for the reconstruction of the history of Blake Sea and of Salton Lake.

The carvings were apparently not made in the granite, but in the travertine, and extended study may be necessary to determine the depth at which the figures were made, and what deposition and weathering has since taken place. The facts favor the presumption that Blake Sea was a fluctuating body of water and not a continuously receding one. The final proof of the matter will rest chiefly upon biological evidence concerning the activities of organisms in connection with the deposition of tufas, to which the botanist may be expected to contribute.

D. T. MacDougal,
Godfrey Sykes

Desert Laboratory

SOCIETIES AND ACADEMIES

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the 486th meeting of the society, held April 6, Dr. Gudmund Hatt, of the University of Copenhagen, read a paper entitled "At Home with Lapps and Reindeer," illustrated with lantern slides. About 6,000 of the 30,000 Lapps are nomads and retain much of their old culture, because old habits and thoughts are necessarily connected with their nomadic life. The Lappish world is full of supernatural powers that seem to be recruited from the ghosts of the dead. An underground people, generally invisible, called "saivo," are believed to be reindeer breeders. The shaman sometimes goes to the saivo world to secure the recovery of a sick person and until recently offerings were made to it to prolong life. Vagrant spirits, "muones," bring sickness. There are also local spirits, not spirits of the dead, who inhabit and own certain localities. Every part of the lodge is connected with supernatural powers. The place behind the fire is sacred. Lapps are considered great magicians, the main purposes of their art being to bring sickness and death and to cure sickness. The evil influences that bring sickness are driven away by terrifying the hostile power. Again, the sick part may be touched by the object from which the evil came, in order to cure it. The idea of reindeer luck is characteristic. Until lately, sacrifices were in vogue to insure it. No bone must be broken in the sacrifices of reindeer. The bones were formerly sometimes placed in a spring. Formerly the same deity presided over the birth of children and of reindeer calves. To take the life of a human being will buy reindeer luck.

At the 487th regular and 36th annual meeting of the society, held April 20, Dr. Henry R. Evans, of the Bureau of Education, read a paper on "The Old and New Magic." In addition to explanations given in his book under this title, the doctor explained that thought transference and even hypnotism might be the real explanation of the phenomena exhibited by so-called mediums and clairvoyants. Dr. Gudmund Hatt said that Lapps caused and cured sickness through hypnotism and practised second sight. Mr. Mooney gave instances of hypnotism as practised by medicine men among American Indians. Mr. J. N. B. Hewitt, Mr. Francis La Flesche, and Dr. E. L. Morgan related their observations upon sleight-of-hand and other tricks practised among the Iroquois, the Pawnees, and other tribes. For example, "arrows" made of pliable vines were swallowed; also other objects by means of a tube inserted in the throat. Iroquois jugglers forfeited their life unless each produced a new trick at the annual meeting of the jugglers and correctly told the dreams of others.

The following officers were elected for the ensuing year: Dr. John R. Swanton, President; Dr. I. M. Casanowicz, Vice-president; Dr. Daniel Folkmar, Secretary; Mr. J. N. B. Hewitt, Treasurer; and Messrs. William A. Babcock, Francis La Flesche, George C. Maynard and Felix Neumann, and Dr. Edwin L. Morgan were elected Councilors.

Daniel Folkmar,
Secretary